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THE NASTRAN® USER'S MANUAL

(Level 17.0)

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1. STRUCTURAL MODELING

1.1 INTRODUCTION

NASTRAN embodies a lumped element approach, wherein the distributed physical properties of a structure are represented by a model consisting of a finite number of idealized substructures or elements that are interconnected at a finite number of grid points, to which loads are applied. All input and output data pertain to the idealized structural model. The major steps in the definition and loading of a structural model are indicated in Figure 1.

As indicated in Figure 1, the grid point definition forms the basic framework for the structural model. All other parts of the structural model are referenced either directly or indirectly to the grid points.

Two general types of grid points are used in defining the structural model. They are:

1. Geometric grid point - a point in three-dimensional space at which three components of translation and three components of rotation are defined. The coordinates of each grid point are specified by the user.
2. Scalar point - a point in vector space at which one degree of freedom is defined. Scalar points can be coupled to geometric grid points by means of scalar elements and by constraint relationships.

The structural element is a convenient means for specifying many of the properties of the structure, including material properties, mass distribution and some types of applied loads. In static analysis by the displacement method, stiffness properties are input exclusively by means of structural elements. Mass properties (used in the generation of gravity and inertia loads) are input either as properties of structural elements or as properties of grid points. In dynamic analysis, mass, damping, and stiffness properties may be input either as the properties of structural elements or as the properties of grid points (direct input matrices).

Structural elements are defined on connection cards by referencing grid points, as indicated on Figure 1. In a few cases, all of the information required to generate the structural matrices for the element is given on the connection card. In most cases the connection card refers to a property card, on which the cross-sectional properties of the element are given. The property card in turn refers to a material card which gives the material properties. If some of the material properties are stress dependent or temperature dependent, a further reference is made to tables for this information.

Various kinds of constraints can be applied to the grid points. Single-point constraints are used to specify boundary conditions, including enforced displacements of grid points.

Multipoint constraints and rigid elements are used to specify linear relationships among selected degrees of freedom. Omitted points are used as a tool in matrix partitioning and for reducing the number of degrees of freedom used in dynamic analysis. Free-body supports are used to remove stress-free notions in static analysis and to evaluate the free-body inertia pooperties of the structural model.

Static loads may be applied to the structural model by concentrated loads at grid points, pressure loads on surfaces, or indirectly, by means of the mass and thermal expansion properties of structural elements are enforced deformations of one-dimensional structural elements. Due to the great variety of possible sources for dynamic loading, only general forms of loads are provided to the user in dynamic analysis.

The following sections describe the general procedures for defining structural models. Detailed instructions for each of the bulk data cards and case control cards are given in Section 2. Additional information on the case control cards and use of parameters is given for each rigid format in Section 3.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

PAGE STATUS LOG

List of Pages Changed, Replaced, or Added

Page No.	Page No.	Page No.
Cover Page	2.3-57	2.4-109
iii - xiv	2.3-58a and 2.3-58b	2.110
1.1-1	2.4-4fa	2.4-110a and 2.4-110b
1.1-2	2.4-4fc	2.4-113
1.1-3	2.4-4g	2.4-114
1.3-5 thru 1.3-8	2.4-4i	2.4-114a and 2.4-114b
1.3-12	2.4-5	2.4-116a
1.3-14c	2.4-7	2.4-116c
1.3-14d	2.4-8b	2.4-135
1.3-14j	2.4-11	2.4-140a
1.3-14k	2.4-13	2.4-141
1.3-14ℓ	2.4-15	2.4-147
1.3-15	2.4-17	2.4-149
1.3-17	2.4-19	2.4-151
1.3-18	2.4-21	2.4-153
1.3-25	2.4-23	2.4-154a
1.4-1 thru 1.4-9	2.4-25	2.4-154c
1.5-4	2.4-27	2.4-154e
1.5-5	2.4-28d	2.4-154f
1.8-1 thru 1.8-8	2.4-36e	2.4-163
1.10-1 thru 1.10-76	2.4-56a	2.4-165
1.11-9	2.4-56c	2.4-167
1.14-1	2.4-62a	2.4-169 thru 2.4-176
2.1-1 thru 2.1-4	2.4-62c	2.4-179
2.2-2 thru 2.2-6	2.4-62e	2.4-182a
2.3-1 thru 2.3-3a	2.4-62f	2.4-184a and 2.4-184b
2.3-14 thru 2.3-17	2.4-62g	2.4-185
2.3-18b thru 2.2-20b	2.4-62h	2.4-192d
2.3-22	2.4-78a and 2.4-78b	2.4-194a
2.3-24	2.4-82a and 2.4-82b	2.4-203
2.3-25	2.4-82c and 2.4-82d	2.4-226a thru 2.4-226d
2.3-26	2.4-87	2.4-230a and 2.4-230b
2.3-29	2.4-98	2.4-235
2.3-31	2.4-98b	2.4-236a
2.3-31a and 2.3-31b	2.4-100	2.4-236c
2.3-34	2.4-103	2.4-236g thru 2.4-236l
2.3-35a and 2.3-35b	2.4-106	2.4-236m
2.3-38 thru 2.3-38b	2.4-107	2.4-241
2.3-44 thru 2.3-46	2.4-108	2.4-243

PAGE STATUS LOG (Continued)

List of Pages Changed, Replaced, or Added

Page No.	Page No.	Page No.
2.4-254a	2.7-14	3.17-1 thru 3.17-12
2.4-254c	2.7-20	3.18-1 thru 3.18-9
2.4-257	2.7-20a	3.19-1 thru 3.19-14
2.4-259	2.7-22 thru 2.7-26	3.20-1 thru 3.20-20
2.4-261	2.7-26b	3.21-1 thru 2.21-21
2.4-263	2.7-27 thru 2.7-33	4.1-1 thru 4.1-5
2.4-264a	3.1-1	4.2-1 thru 4.2-5
2.4-264ba	3.1-2	4.2-7 thru 4.2-17
2.4-264bc	3.2-1 thru 3.2-15	4.2-19
2.4-264be	3.3-1 thru 3.3-8	4.2-20
2.4-264c	3.3-10 thru 3.3-12	4.3-2 thru 4.3-11
2.4-264e	3.4-1 thru 3.4-8	4.3-13
2.4-269	3.4-10	4.3-17
2.4-271	3.4-13 thru 3.4-16	4.3-18
2.4-273	3.5-1 thru 3.5-20	5.1-1
2.4-275	3.6-1 thru 3.6-10	5.2-2
2.4-277	3.6-12 thru 3.6-14	5.2-6
2.4-293	3.6-16	5.3-1
2.4-297	3.7-1 thru 3.7-13	5.3-3
2.4-301	3.7-15	5.4-1
2.4-303	3.8-1 thru 3.8-10	5.4-4
2.4-305	3.8-12 thru 3.8-14	5.4-9
2.4-306	3.8-16 thru 3.8-18	5.4-10
2.4-306a	3.9-1 thru 3.9-20	5.4-12 thru 5.4-15
2.4-307	3.10-1 thru 3.10-11	5.4-19
2.5-1	3.10-13 thru 3.10-17	5.4-20
2.6-1	3.11-1 thru 3.11-8	5.5-1
2.6-2	3.11-10 thru 3.11-12	5.5-12
2.6-7	3.11-14	5.5-12a and 5.5-12b
2.6-8	3.12-1 thru 3.12-19	5.5-23
2.6-10	3.13-1 thru 3.13-10	5.5-25
2.6-11	3.13-13 thru 3.13-16	5-5-30 thru 5.5-32b
2.6-13	3.13-18	5.5-36
2.6-14	3.14-1 thru 3.14-21	5.5-40 thru 5.5-42
2.6-18	3.15-1 thru 3.15-9	5.5-43b
2.6-23	3.15-11 thru 3.15-14	5.5-44
2.6-24	3.16-1 thru 3.16-10	5.5-49
2.7-10	3.16-13	5.8-10
2.7-11	3.16-14	5.9-12

PAGE STATUS LOG (Continued)

List of Pages Changed, Replaced, or Added

Page No.

5.10-1 thru 5.10-7
6.1-1
6.1-3
6.1-6
6.1-9
6.2-4
6.2-6
6.2-7
6.2-7a and 6.2-7b
6.2-9 thru 6.2-11b
6.2-13 thru 6.2-16

Page No.

6.2-18c thru 6.2-18j
6.2-20
6.2-23
6.2-23a and 6.2-23b
6.2-28b
6.2-28d
6.2-28e
6.2-28eb
6.2-28g thru 6.2-28p
6.2-31
6.2-33

Page No.

6.2-33a thru 6.2-33j
6.2-35a and 6.2-35b
6.2-36
6.2-37a and 6.2-37b
6.2-41
6.2-42
6.2-44
6.2-45
6.2-48 thru 6.2-54
7.1-1 thru 7.1-64

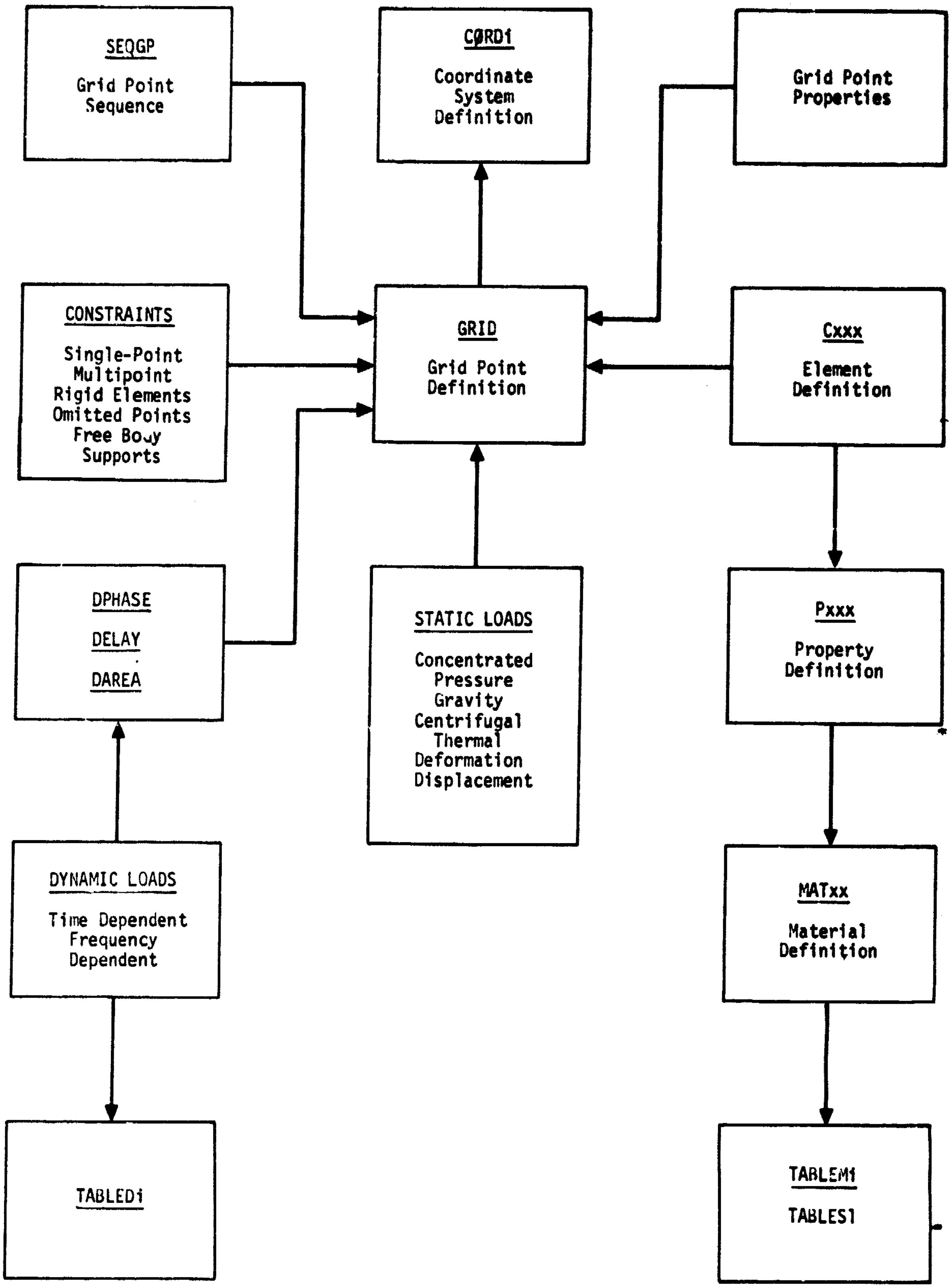

Figure 1. Structural model.

1.3.4 Shear Panels and Twist Panels

The shear panel is defined with a CSHEAR card and its properties with a PSHEAR card. A shear panel is a two-dimensional structural element that resists the action of tangential forces applied to its edges, but does not resist the action of normal forces. The structural and nonstructural mass of the shear panel are lumped at the connected grid points. Details of the shear panel element are discussed in Section 5.3 of the Theoretical Manual.

The element coordinate system for a shear panel is shown in Figure 3a. The integers 1, 2,3, and 4 refer to the order of the connected grid points on the CSHEAR card. The element forces are output on request in either the real or complex form. The positive directions for these forces are indicated in Figure 3b. These forces consist of the forces applied to the element at the corners in the direction of the sides, kick forces at the corners in a direction normal to the plane formed by the two adjacent edges, and "shear flows" (force per unit length) along the four edges. The shear stresses are calculated at the corners in skewed coordinates parallel to the exterior edges. The average of the four corner stresses and the maximum stress are output on request in either the real or complex form. A margin of safety is also output when the stresses are real.

The twist panel performs the same function for bending action that the shear panel performs for membrane action. The twist panel is defined with a CTWIST card and its properties with a PTWIST card. In calculating the stiffness matrix, a twist panel is assumed to be solid. For built-up panels, the thickness in the PTWIST card must be adjusted to give the correct moment of inertia of the cross-section. If mass calculations are being made, the density will also have to be adjusted on a MAT1 card. The element coordinate system and directions for positive forces are shown in Figure 4. Stress recovery is similar to that for shear panels.

1.3.5 Plate and Membrane Elements

NASTRAN includes two different shapes of plate and membrane elements (triangular and quadrilateral) and two different stress systems (inplane and bending) which are uncoupled. There are different forms of elements available that are defined by connection cards as follows:

1. Plate (Bending) Elements

    a. CTRBSC - basic unit from which the bending properties of the other plate elements are formed.

    b. CTRPLT - triangular element with zero inplane stiffness and finite bending stiffness.

   c. CTRPLT1 - a higher order triangular element with zero inplane stiffness and finite bending stiffness. Uses quintic polynomial representation for transverse displacements and bilinear variation for temperature and thickness.

   d. CQDPLT - quadrilateral element with zero inplane stiffness and finite bending stiffness.

2. Membrane (Inplane) Elements

   a. CTRMEM - triangular element with finite inplane stiffness and zero bending stiffness.

   b. CTRIM6 - triangular element with finite inplane stiffness and zero bending stiffness. Uses quadratic polynomial representation for membrane displacements and bilinear variation for temperature and thickness.

   c. CQDMEM - quadrilateral element consisting of four overlapping CTRMEM elements.

   d. CQDMEM1 - an isoparametric quadrilateral membrane element.

   e. CQDMEM2 - a quadrilateral membrane element consisting of four nonoverlapping CTRMEM elements.

3. Plate and Membrane Elements

   a. CTRIA1 - triangular element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

   b. CTRIA2 - triangular element with both inplane and bending stiffness that assumes a solid homogeneous cross-section.

   c. CQUAD1 - quadrilateral element with both inplane and bending stiffness. It is designed for sandwich plates which can have different materials referenced for membrane, bending and transverse shear properties.

   d. CQUAD2 - quadrilateral element with both inplane and bending stiffness that assumes a solid homogeneous cross-section.

Theoretical aspects of these elements are treated in Section 5.8 of the Theoretical Manual.

The properties for the above elements are defined on their associated Pxxxxxx cards (PTRBSC, PTRPLT, etc.). All of the properties of the elements are assumed uniform over their surfaces except the CTRIM6 and CTRPLT1. Anisotropic material may be specified for all these elements. Transverse shear flexibility may be included for all bending elements on an optional basis, except for homogeneous elements (CTRIA2 and CQUAD2), where this effect is automatically included. Structural mass is calculated only for elements that specify a membrane thickness and is based only on the membrane thickness. Nonstructural mass can be specified for all plate elements, except the basic bending triangle. Only lumped mass procedures are used for membrane elements. Coupled mass procedures may be requested for elements that include bending stiffness with the PARAM card CØUPMASS (see PARAM bulk data card). Differential stiffness matrices are generated for the following elements: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2. The following elements

may have nonlinear material characteristics in Piecewise Linear Analysis: CTRMEM, CTRIA1, CTRIA2, CQDMEM, CQUAD1, CQUAD2.

The element coordinate systems for the triangular and quadrilateral elements are shown in Figure 5. The integers 1, 2, 3, and 4 refer to the order of the connected grid points on the connection cards defining the elements. A similar connection scheme for elements with mid-side grid points would be defined by six integers on the connection card. The angle θ is the orientation angle for anisotropic materials.

Average values of element forces are calculated for all plate elements (except the CTRPLT1) having a finite bending stiffness. The element forces for the CTRPLT1 are calculated at the corners and centroid of the element. The positive directions for plate element forces in the element coordinate system are shown in Figure 6a. The following element forces per unit of length, either real or complex, are output on request:

1. Bending moments on the x and y faces.

2. Twisting moment.

3. Shear forces on the x and y faces.

The CQDMEM2 is the only membrane element for which element forces are calculated. The positive directions for these forces are shown in Figure 3b, and the force output has the same interpretation as the force output for the shear palen discussed previously.

Average values of the membrane stresses are calculated for the triangular and quadrilateral membrane elements, with the exception of the CQDMEM1 and CTRIM6 elements. For the CQDMEM1 element, in which the stress field varies, the stresses are evaluated at the intersection of diagonals (in a mean plane if the element is warped.) For the CTRIM6 element, the stresses are calculated at the corners and centroid of the element. The positive directions for the membrane stresses are shown in Figure 6b. The stresses for the CQDMEM2 element are calculated in the material coordinate system. The material coordinate system is defined by the material orientation angle on the CQDMEM2 card. The stresses for all other membrane elements are calculated in the element coordinate system.

The following real membrane stresses are output on request:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

Only the normal stresses and shearing stress are available in the complex form.

If an element has bending stiffness, the average stresses are calculated on the two faces of the plate for homogeneous plates and at two specified points on the cross-section for other plate elements. The distances to the specified points are given on the property cards. The positive directions for these fiber distances are defined according to the right-hand sequence of the grid points specified on the connection card. These distances must be nonzero in order to obtain nonzero stress output. The same stresses are calculated for each of the faces as are calculated for membrane elements.

The quadrilateral elements are intended for use when the surfaces are reasonably flat and the geometry is nearly rectangular. For these conditions, the quadrilateral elements eliminate the modeling bias associated with the use of triangular elements, and quadrilaterals give more accurate results for the same mesh size. If the surfaces are highly warped, curved or swept, triangular elements should be used. Under extreme conditions quadrilateral elements will give results that are considerably less accurate than triangular elements for the same mesh size. Quadrilateral elements should be kept as nearly square as practicable, as the accuracy tends to deteriorate as the aspect ratio of the quadrilateral increases. Triangular elements should be kept as nearly equilateral as practicable, as the accuracy tends to deteriorate as the triangles become obtuse and as the ratio of the longest to the shortest side increases.

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1.3.6 Axisymmetric Shell Elements

The properties of axisymmetric shells can be specified with either of two elements, the conical shell (CØNEAX) or the toroidal ring (TØRDRG). However, these cannot be used together in the same model. Also available for thick shells of revolution are the axisymmetric solid elements (TRIARG, TRAPRG, TRIAAX, and TRAPAX) which are described in the next section. Thin shell (TRSHL) modeling is described in Section 1.3.12.

The properties of the conical shell element are assumed to be symmetrical with respect to the axis of the shell. However, the loads and deflections need not be axisymmetric, as they are expanded in Fourier series with respect to the aximuthal coordinate. Due to symmetry, the resulting load and deformation systems for different harmonic orders are independent, a fact that results in a large time saving when the use of the conical shell element is compared with an equivalent model constructed from plate elements. Theoretical aspects of the conical shell element are treated in Section 5.9 of the Theoretical Manual.

The conical shell element may be combined with TRIAAX and TRAPAX elements only. The existence of a conical shell problem is defined by the AXIC card. This card also indicates the number of harmonics desired in the problem formulation. Only a limited number of bulk data cards are allowed when using conical shell elements. The list of allowable cards is given on the AXIC card description in Section 2.4.2.

The geometry of a problem using the conical shell element is described with RINGAX cards instead of GRID cards. The RINGAX cards describe concentric circles about the basic z-axis, with their locations given by radii and z-coordinates as shown in Figure 7. The degrees of freedom defined by each RINGAX card are the fourier coefficients of the motion with respect to angular position around the circle. For example the radial motion, u_r, at any angle, ϕ, is described by the equation:

$$u_r(\phi) = \sum_{n=0}^{N} u_r^n \cos n\phi + \sum_{n=0}^{N} u_r^{n*} \sin n\phi \,, \qquad (1)$$

where u_r^n and u_r^{n*} are the fourier coefficients of radial motion for the n-harmonic. For calculation purposes the series is limited to N harmonics as defined by the AXIC card. The first sum in the above equation describes symmetric motion with respect to the $\phi = 0$ plane. The second sum with the "starred" (*) superscripts describes the antisymmetric motion. Thus each RINGAX data card will produce six times (N+1) degrees of freedom for each series.

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3. Angle between the u-axis and the major principal axis
4. Major and minor principal stresses
5. Maximum shear stress

The coordinate system for the toroidal ring is shown in Figure 8. This cylindrical coordinate system is implied by the use of the toroidal element, and hence, no explicit definition is required. The toroidal element may use orthotropic materials. The axes of orthotropy are assumed to coincide with the element coordinate axes.

Deformation behavior of the toroidal element is described by five degrees of freedom for each of the two grid rings which it connects. The degrees of freedom in the implicit coordinate system are:

1. $\bar{u}$ - radial displacement
2. Not defined for toroidal element (must be constrained)
3. $\bar{w}$ - axial displacement
4. $w' = \frac{\partial w}{\partial \xi}$ slope in ξ-direction
5. $u' = \frac{\partial u}{\partial \xi}$ strain in ξ-direction
6. $w'' = \frac{\partial^2 w}{\partial \xi^2}$ curvature in $z\xi$-plane

The displacements $\bar{u}$ and $\bar{w}$ are in the basic coordinate system, and hence can be expressed in other local coordinate systems if desired. However, the quantities u', w' and w" are always in the element coordinate system.

The toroidal ring element connectivity is defined with a CTØRDRG card and its properties with a PTØRDRG card and, in the limit, this element becomes a cap element (see Section 5.10 of the Theoretical Manual). The integers 1 and 2 on Figure 8 refer to the order of the connected grid points on the CTØRDRG card The grid points must lie in the r-$\bar{z}$ plane of the basic coordinate system and they must lie to the right of the axis of symmetry. The angles α_1 and α_2 in Figure 8 are the angles of curvature and are defined as the angle measured in degrees from the axis of symmetry to a line which is perpendicular to the tangent to the surface at grid points 1 and 2 respectively. For conic rings $\alpha_1 = \alpha_2$ and for cylindrical rings $\alpha_1 = \alpha_2 = 90$ degrees. Toroidal elements may be connected to form closed figures in the r-$\bar{z}$ plane, but slope discontinuities are not permitted at connection points.

The following forces, evaluated at each end of the toroidal element, are output on request:

1. Radial force
2. Axial force
3. Meridional moment
4. A generalized force which corresponds to the w' degree of freedom.
5. A generalized force which corresponds to the w" degree of freedom.

The first three forces are referenced to the global coordinate system and the two generalized forces are referenced to the element coordinate system. For a definition of the generalized forces see Section 5.10 of the Theoretical Manual.

The following stresses, evaluated at both ends and the midspan of each element, are output on request:

1. Tangential membrane stress (Force per unit length)
2. Circumferential membrane stress (Force per unit length)
3. Tangential bending stress (Moment per unit length)
4. Circumferential bending stress (Moment per unit length)
5. Shearing stress (Force per unit length)

The positive directions for these stresses are indicated in Figure 9.

1.3.7 Axisymmetric Solid Elements

Two sets of elements are provided for representing thick axisymmetric shell and/or solid structures (see Section 5.11 of the Theoretical Manual). The first set, the triangular ring TRIARG and trapezoidal ring TRAPRG, is restricted to axisymmetric applied loadings only. The second set is not restricted to axisymmetric loadings and, like the conical shell element, their displacements and loads are represented by coefficients of a Fourier series about the circumference. These elements, the TRIAAX and the TRAPAX, also define a triangular and a trapezoidal cross section respectively. The elements of one set may not be used together with elements of the other set nor with any other elements except the combination of TRIAAX and TRAPAX elements with the conical shell element (CØNEAX).

The triangular and trapezoidal ring elements may be used for modeling axisymmetric thick-walled structures of arbitrary profile. In the limiting case only the TRAPRG element may become a solid core element.

be made by direct matrix input through DMIG cards. The information from these several sources will be summed in the formation of the final mass matrix.

1.3.9.4 Output from the Grid Point Weight Generator

The Grid Point Weight Generator (GPWG) module computes the rigid body mass properties of an entire structure with respect to a user specified point and with respect to the center of mass.

Output from the module is requested by a PARAM card in the Bulk Data Deck which specifies from which grid point mass computations are to be referenced. Optionally, the absence of a specific grid point automatically causes the origin of the basic coordinate system to be utilized as a reference. The mass properties are initially defined in the basic coordinate system. Subsequently, the mass properties are transformed to principal mass axes and to principal inertia axes. The actual printout is composed of several elements. These are

1. Title MØ - RIGID BØDY MASS MATRIX IN BASIC CØØRDINATE SYSTEM

This is the rigid body mass matrix of the entire structure in the basic coordinate system with respect to a reference point chosen by the analyst.

2. Title S - TRANSFØRMATION MATRIX FØR SCALAR MASS PARTITIØN

S is the transformation from the basic coordinate system to the set of principal axes for the 3 x 3 scalar mass partition of the 6 x 6 mass matrix. The principal axes for just the scalar partition are known as the principal mass axes.

3. Title X-C.G. Y-C.G. Z-C.G.

It is possible in NASTRAN to assemble a structural model having different values of mass in each coordinate direction at a grid point. This can arise for example assembling scalar mass components or from omitting some components by means of bar element pin flags. Consequently three distinct mass systems are assembled one in each of the three directions of the principal mass axes (the S system). This third tabulation has five columns. The first column lists the axis direction in the S coordinates. The second column lists the mass associated with the appropriate axis direction. The final three columns list the x, y and z coordinate distances from the reference point to the center of mass for each of the three mass systems.

4. Title I(S) - INERTIAS RELATIVE TØ C.G.

This is the 3 x 3 mass moment of inertia partition with respect to the center of gravity referred to the principal mass axes (the S system). This is not necessarily a diagonal matrix because the determination of the S system does not involve second moments. The values of

inertias at the center of gravity are found from the values at the reference point by employing the parallel axes rule.

5. Title I(Q) - PRINCIPAL INERTIAS

The principal moments of inertia at the center of gravity are displayed in matrix form with reference to the Q system of axes. The Q system is obtained from an eigenvalue analysis of the I(s) matrix.

6. Title Q - TRANSFØRMATION MATRIX --I(Q) = QT*I(S)*Q

Q is the coordinate transformation between the S axes and the Q axes.

1.3.9.5 Bulk Data Cards for Mass

A summary chart is given in Table 1 to help in the selection of the method of input for a given type of mass information. Descriptions of individual cards for the entering of mass information into the bulk data are listed here:

1. Element data from the combined sources of C(-), P(-), and MATi cards will automatically cause the translational mass (scalar) terms of the mass matrix to be generated, provided a density value and/or a nonstructural density factor is entered.
2. The MASSi cards define scalar masses. CMASSi cards define connections between a pair of degrees of freedom (at either scalar or geometric grid points) or between one degree of freedom and ground. Thus, $f_1 = m(x_1 - x_2)$ where x_2 may be absent. The CMASS1 cards (i = 1 through 4) are necessary whenever scalar points are used. PMASSi cards define mass property magnitudes. Other applications include selective representations of inertia properties, such as occur in shell theory where in-plane inertia forces are often ignored.
3. The CØNM2 card defines the properties of a solid body: m, its mass, x_1, x_2, x_3, the three coordinates of its center of gravity offset with respect to the grid point, I_{11}, I_{22}, I_{33}, its three moments of inertia and I_{12}, I_{13}, I_{23}, and its three products of inertia, all with respect to any (selected) coordinate system. If a local cylindrical or a spherical coordinate system is chosen to define the mass properties, the offset distances of the mass c.g. from the grid point are measured along the axes(r,Θ,z or ρ,Θ,Φ) defined at the grid point in that local system. Also note, that the mass properties of inertia are computed relative to a set axes at the mass c.g. which are <u>parallel</u> to those r,Θ,z or ρ,θ,ϕ axes at that grid point. The CØNM2 element routine uses the parallel axis theorem to

1.3.11 Isoparametric Solid Hexahedron Elements

Three types of isoparametric solid hexahedron elements are provided for general solid structures. These elements (see Figure 13) are a linear, a quadratic, and a cubic isoparametric hexahedron. The theory is given in Section 5.13 of the Theoretical Manual. These elements can be used with all other NASTRAN elements, except the axisymmetric elements. Connections are made only to the translational degrees of freedom at the grid points. The elements are defined by CIHEX1, CIHEX2, and CIHEX3 connection cards. All three of these cards reference the PIHEX property card.

The isoparametric solid hexahedron elements allow the user to accurately define a structure with fewer elements and grid points than might otherwise be necessary with simple constant strain solid elements. The linear element generally gives best results for problems involving mostly shear deformations, and the higher order elements give good results for problems involving both shearing and bending deformations. Only a coupled mass matrix is generated to retain the inherent accuracy of the elements. Temperature, temperature-dependent material properties, displacements, and stresses may vary through the volume of the elements. The values at interior points of the element are interpolated using the isoparametric shape function. For best results, the applied grid point temperatures should not have more than a "gentle" quadratic variation in each of the three dimensions of the element. If the element has non-uniform applied temperatures, or if it is not a rectangular parallelopiped, three or more integration points should be specified on the PIHEX card. Severely distorted element shapes should be avoided.

Stiffness, mass, differential stiffness, structural damping, conductance, and capacitance matrices may be generated with these elements. Piecewise linear analysis has not been implemented.

The output stresses are given in the basic coordinate system. The stresses are assumed to vary through the element. Therefore, stresses are computed at the center and at each corner grid point of these elements. For the quadratic and cubic elements, they are also computed at the midpoint of each edge of the element. In addition to the six normal and shear stresses, output also includes the principal stresses (S_x, S_y, and S_z), the direction cosines of the principal planes, the mean stress

$$\sigma_n = -\frac{1}{3}(\sigma_x + \sigma_y + \sigma_z) \quad ,$$

and the octahedral shear stress

$$\sigma_o = \left\{\frac{1}{3}\left[(S_x + \sigma_n)^2 + (S_y + \sigma_n)^2 + (S_z + \sigma_n)^2\right]\right\}^{1/2}$$

1.3.12 Shallow Shell Element

A higher order shallow triangular shell element (TRSHL) formulated from the TRIM6 and TRPLT1 elements is available. The inplane and bending properties are coupled and the geometry of the element may be curved. If the element is flat and either the inplane or bending properties are negligible, the element degenerates to the TRPLT1 or TRIM6 element, respectively.

The element has grid points at the vertices and at the midpoints of the sides of the triangle (see Figure 14). At each grid point, there are five degrees of freedom in the element coordinate system; viz., the membrane displacements, u and v, parallel to the x and y axes, the transverse displacement, w, in the z-direction normal to the x-y plane (with positive direction outward from the paper) and the rotations of the normal to the shell, α and β, about the x-z and y-z planes (with positive directions following from the right-hand rule). The element, thus, has 30 degrees of freedom in the element coordinate system.

The membrane displacements, u and v, for the shell are expressed as quadratic polynomials and are the same as for the higher order membrane triangular element, TRIM6. The displacement function for the normal deflection, w, is taken as a quintic polynomial as in the higher order bending triangular element, TRPLT1. The geometry of the shell surface is approximated by a quadratic polynomial in basic coordinates. Shallow shell theory is used to include the membrane-bending coupling effects. Thus, the element should be used only in cases where the shell is truly shallow. However, reasonably good accuracy is seen even when the elements are used to analyze shells that are only marginally shallow. The user is cautioned, however, to be careful while interpreting results obtained when the shell analyzed is very deep. Due to the excessive computation time associated with such calculations, the transverse shear flexibility is not taken into account in the element formulation. Further discussion of this element is treated in Section 5.14 of the Theoretical Manual.

The connectivity of this element is described by a CTRSHL card and the properties are defined by a PTRSHL card. The element may be used in the statics, normal modes, and differential stiffness rigid formats. Loads may be mechanical or thermal.

Element forces per unit width are output for the following quantities:

1. Bending moments on the x and y faces
2. Twisting moment
3. Shear forces on the x and y faces

The element forces are calculated at the three corners and the centroid. The sign conventions for these forces are the same as previously discussed in Section 1.3.5.

Stresses are output for the following quantities:

1. Normal stresses in the x and y directions
2. Shear stress on the x face in the y direction
3. Angle between the x-axis and the major principal axis
4. Major and minor principal stresses (zero shear)
5. Maximum shear stress

The stresses will be calculated at the specified fibre distances from the elastic axis defined on the property card and are always calculated at the top and bottom fibres for the centroid of the element. The sign conventions for the stresses are the same as previously discussed in Section 1.3.5.

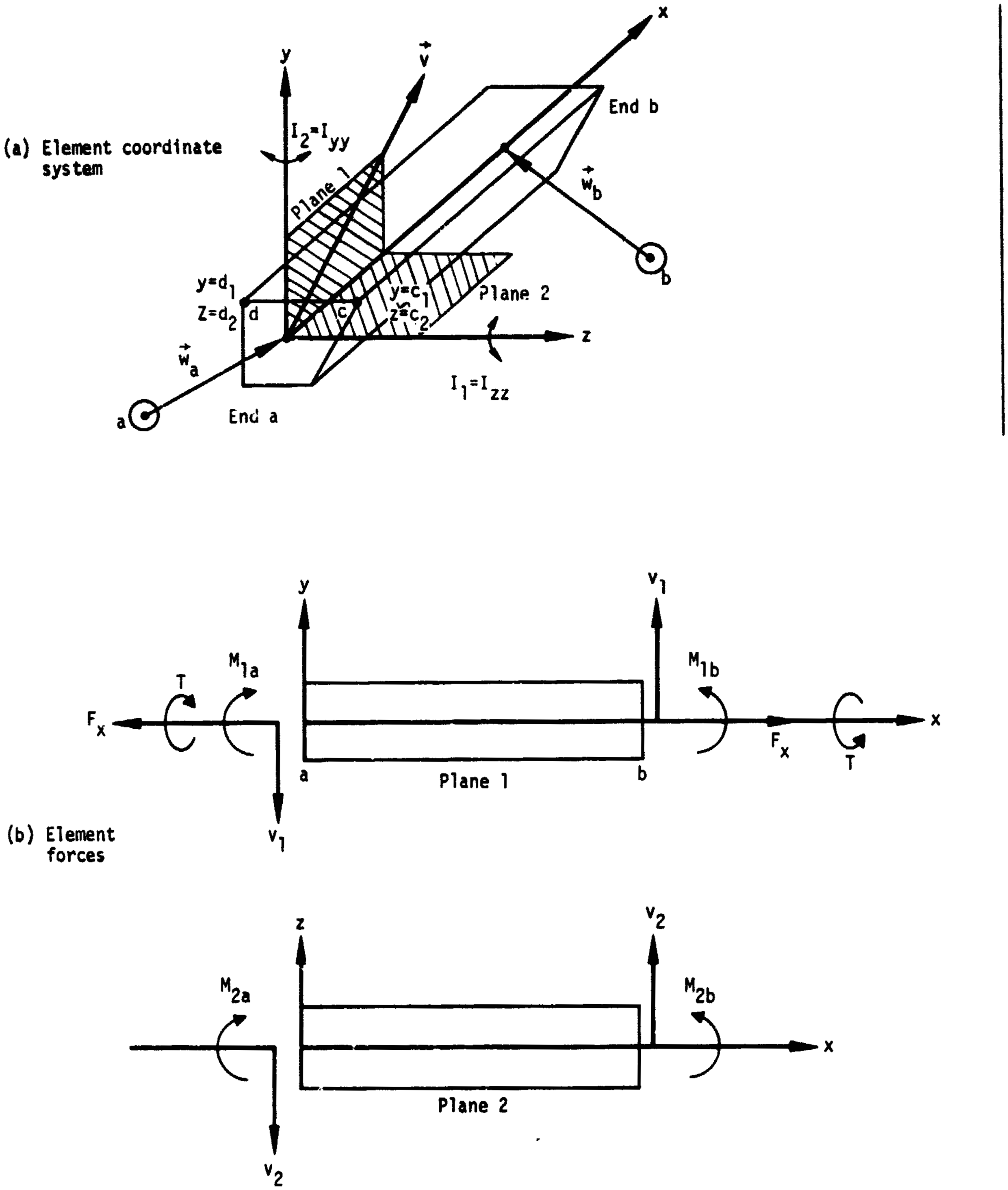

Figure 1. Bar element coordinate system and element forces.

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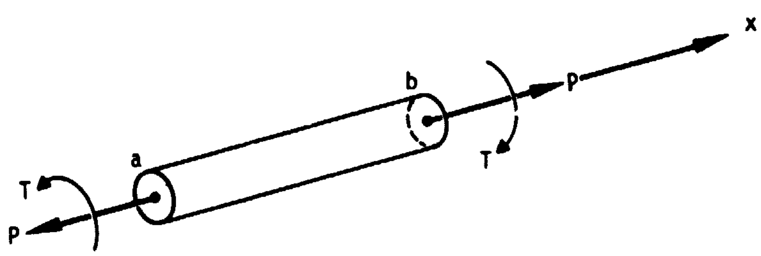
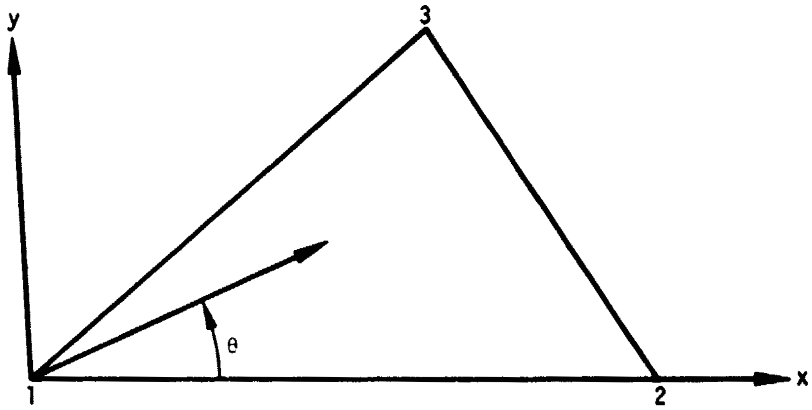
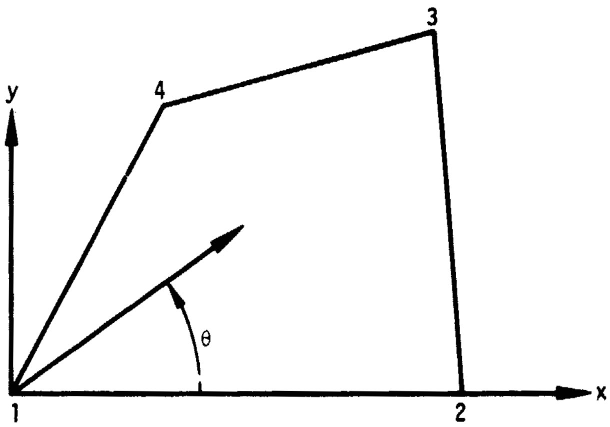


Figure 2. Rod element coordinate system and element forces.

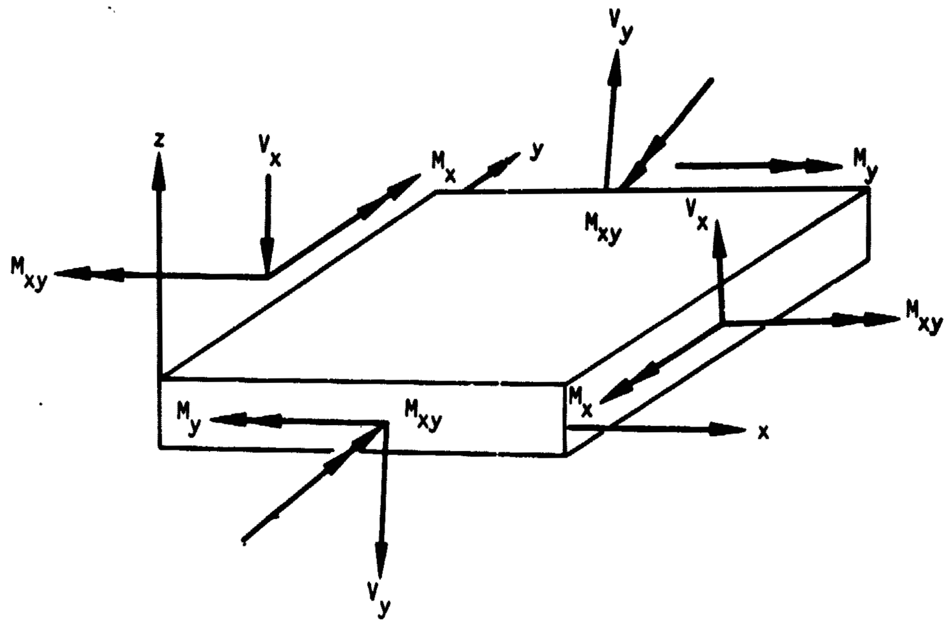


(a)

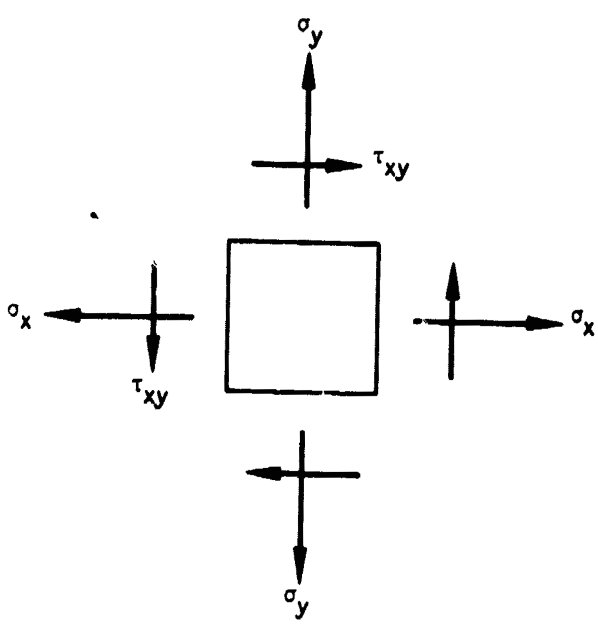


(b)

Figure 5. Plate and membrane element coordinate systems.



(a) Plate element forces.



(b) Membrane element stresses.

Figure 6. Forces and stresses in plate and membrane elements.

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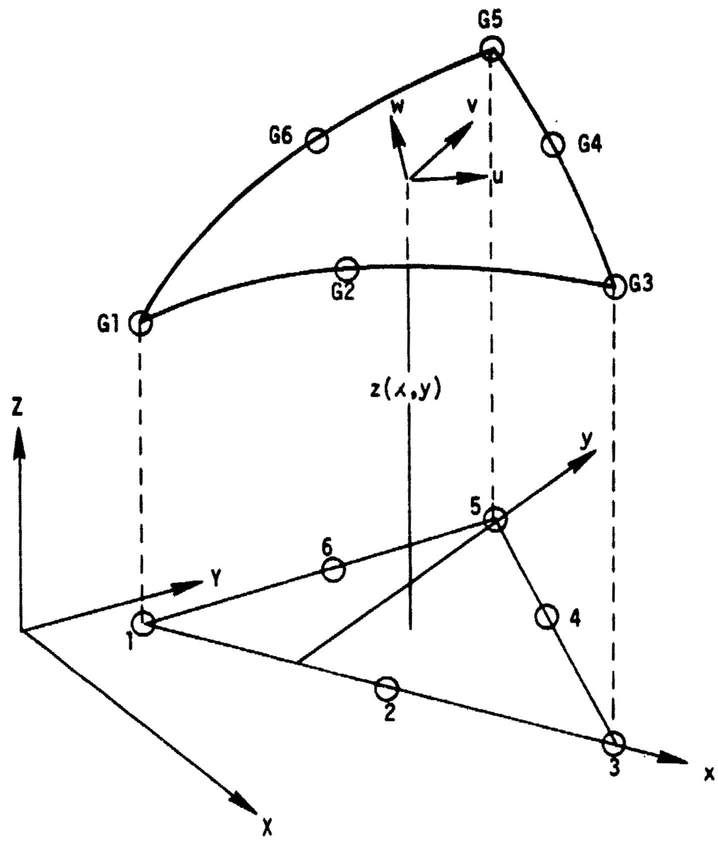


Figure 14. Triangular shallow shell element geometry and coordinate systems.

1.4 CONSTRAINTS AND PARTITIONING

Structural matrices are initially assembled in terms of all structural grid points, which excludes only the extra scalar points introduced for dynamic analysis. These matrices are generated with six degrees of freedom for each geometric grid point and a single degree of freedom for each scalar point. Various constraints are applied to these matrices in order to remove undesired singularities, provide boundary conditions, define rigid elements, and provide other desired characteristics for the structural model.

There are two basic kinds of constraints. Single-point constraints are used to constrain a degree of freedom to zero or to a prescribed value; multipoint constraints and rigid elements are used to constrain one or more degrees of freedom to be equal to linear combinations of the values of other degrees of freedom. The following types of bulk data cards are provided for the definition of constraints:

1. Single-point constraint cards
2. Multipoint constraint cards and rigid element connection cards
3. Cards to define reaction points on free bodies
4. Cards to define the omitted coordinates in matrix partitioning

The latter type does not produce constraint forces in static analysis.

1.4.1 Single-Point Constraints

A single-point constraint applies a fixed value to a translational or rotational component at a geometric grid point or to a scalar point. One of the most common uses of single-point constraints is to specify the boundary conditions of a structural model by fixing the appropriate degrees of freedom. Multiple sets of single-point constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. This procedure is particularly useful in the solution of problems having one or more planes of symmetry.

The elements connected to a grid point may not provide resistance to motion in certain directions, causing the stiffness matrix to be singular. Single-point constraints are used to remove these degrees of freedom from the stiffness matrix. A typical example is a planar structure composed of membrane and extensional elements. The translations normal to the plane and all three rotational degrees of freedom must be constrained since the corresponding stiffness matrix

terms are all zero. If a grid point has a direction of zero stiffness, the single-point constraint need not be exactly in that direction, but only needs to have a component in that direction. This allows the use of single-point constraints for the removal of such singularities regardless of the orientation of the global coordinate system. Although the displacements will depend on the direction of the constraint, the internal forces will be unaffected.

One of the tasks performed by the Structural Matrix Assembler (Section 4.27 of the Programmer's Manual) is to examine the stiffness matrix for singularities at the grid point level. An input NASTRAN card entry STST, to control the tolerance, is available. Singularities remaining at this level, following the application of the single-point constraints, are listed in the Grid Point Singularity Table (GPST). This table is automatically printed following the comparison of the possible singularities tabulated by the Structural Matrix Assembler with the single-point constraints and the dependent coordinates of the multipoint constraint equations provided by the user. The GPST contains all possible combinations of single-point constraints, in the global coordinate system, that can be used to remove the singularities. These remaining singularities are treated only as warnings, because it cannot be determined at the grid point level whether or not the singularities are removed by other means, such as general elements or multipoint constraints in which these singularities are associated with independent coordinates. See the GPSPC module description in the Programmer's Manual for automatic removal of singularities.

Single-point constraints are defined on SPC, SPC1, SPCADD, and SPCAX cards. The SPC card is the most general way of specifying single-point constraints. The SPC1 card is a less general card that is more convenient when a number of grid points have the same components constrained to a zero displacement. The SPCADD card defines a union of single-point constraint sets specified with SPC or SPC1 cards. The SPCAX card is used only for specifying single-point constraints in problems using conical shell elements.

Single-point constraints can also be defined on the GRID card. In this case, however, the constraints are part of the model and modifications cannot be made at the subcase level. Also, only zero displacements can be specified on the GRID card.

1.4.2 Multipoint Constraints and Rigid Elements

Multipoint constraints and rigid elements are used to constrain one or more degrees of freedom to be equal to linear combinations of the values of other degrees of freedom. In the former case,

the user must explicitly provide the coefficients of the equations. In the latter case, he provides only the connection data and the program will internally generate the required coefficients.

1.4.2.1 Multipoint Constraints

Each multipoint constraint is described by a single equation that specifies a linear relationship for two or more degrees of freedom. Multiple sets of multipoint constraints can be provided in the Bulk Data Deck, with selections made at execution time by using the subcase structure in the Case Control Deck as explained in Section 2.3.3. Multipoint constraints are discussed in Sections 3.5.1 and 5.4 of the Theoretical Manual.

Multipoint constraints are defined on MPC, MPCADD and MPCAX cards. The MPC card is the basic card for defining multipoint constraints. The first coordinate mentioned on the card is taken as the dependent degree of freedom, i.e. that degree of freedom that is removed from the equations of motion. Dependent degrees of freedom may appear as independent terms in other equations of the set, however, they may appear as dependent terms in only a single equation. The MPCADD card defines a union of multipoint constraint sets specified with MPC cards. The MPCAX card is used only for specifying multipoint constraints in problems using conical shell elements. Some uses of multipoint constraints are:

1. To enforce zero motion in directions other than those corresponding with components of the global coordinate system. In this case, the multipoint constraint will involve only the degrees of freedom at a single grid point. The constraint equation relates the displacement in the direction of zero motion to the displacement components in the global system at the grid point.
2. To describe rigid elements and mechanisms such as levers, pulleys and gear trains. In this application, the degrees of freedom associated with the rigid element that are in excess of those needed to describe rigid body motion are eliminated with multipoint constraint equations. Treatment of very stiff members as being rigid elements eliminates the ill-conditioning associated with their treatment as ordinary elastic elements
3. To be used with scalar elements to generate nonstandard structural elements and other special effects.
4. To describe parts of a structure by local vibration modes. This application is treated in section 14.1 of the Theoretical Manual. The general idea is that the matrix of local eigenvectors represents a set of constraints relating physical coordinates to modal coordinates.

The user provides the coefficients in the multipoint constraint equations defined on MPC, MPCADD, and MPCAX cards.

1.4.2.2 Rigid Elements

Rigid elements provide a convenient means of specifying very stiff connections. The user does not provide the required coefficients directly. The program internally generates them from the connection data. Rigid elements are discussed in Section 3.5.6 of the Theoretical Manual.

Rigid elements are defined on CRIGDR, CRIGD1, CRIGD2, and CRIGD3 cards. The CRIGDR card defines a pin-ended rod element that is rigid in extension-compression. The CRIGD1 card defines a rigid element connection in which all six degrees of freedom of each of the dependent grid points are coupled to all six degrees of freedom of the reference grid point. The CRIGD2 card is more general and defines a connection in which selected degrees of freedom of the dependent grid points are coupled to all six degrees of freedom of the reference grid point. The CRIGD3 card is the most general and defines a rigid element in which selected degrees of freedom of the dependent grid points are coupled to six selected degrees of freedom at one or more (up to six) reference grid points.

On all of the rigid element connection cards, the user specifies the degrees of freedom that belong to the dependent set. This specification is implicit on the CRIGD1 card and explicit on the others. It is important to note that a dependent degree of freedom appearing in a rigid element may not appear as dependent in any other rigid element or on a MPC card nor may it be constrained in any other manner. Also, when using the CRIGD3 card, the user must ensure that the six selected degrees of freedom at the reference grid points together are capable of representing any general rigid body motion of the element.

When using several rigid elements and multipoint constraints, the user will often find it useful to turn on DIAG's 21 and 22 in the Executive Control Deck to obtain the GP4 definition of sets of degrees of freedom.

1.4.3 Free Body Supports

In the following discussion, a free body is defined as a structure that is capable of motion without internal stress, i.e., it has one or more rigid body degrees of freedom. The stiffness matrix for a free body is singular with the defect equal to the number of stress-free, or rigid body modes. A solid three-dimensional body has up to six rigid body modes. Linkages and mechanisms can have a greater number. No restriction is placed in the program on the number of stress-free modes, in order to permit the analysis of mechanisms.

CONSTRAINTS AND PARTITIONING

Free-body supports are defined with a SUPØRT card. In the case of problems using conical shell elements, the SUPAX card is used. In either case, only a single set can be specified, and if such cards appear in the Bulk Data Deck, they are automatically used in the solution. Free-body supports must be defined in the global coordinate system.

In static analysis by the displacement method, the rigid body modes must be restrained in order to remove the singularity of the stiffness matrix. The required constraints may be supplied with single-point constraints, multipoint constraints, or free-body supports. If free-body supports are used, the rigid body characteristics will be calculated and a check will be made on the sufficiency of the supports. Such a check is obtained by calculating the rigid body error ratio as defined in the Rigid Body Matrix Generator operation in Section 3.2.2. This error ratio is automatically printed following the execution of the Rigid Body Matrix Generator. The error ratio should be zero, but may be nonzero for any of the following reasons:

1. Round-off error accumulation
2. Insufficient free-body supports have been provided
3. Redundant free-body supports have been provided

The redundancy of the supports may be caused by improper use of the free-body supports themselves, or by the presence of single-point or multipoint constraints that constrain the rigid body motions.

Static analysis with inertia relief is necessarily made on a model having at least one rigid body motion. Such rigid body motion must be constrained by the use of free-body supports. These supported degrees of freedom define a reference system, and the elastic displacements are calculated relative to the motion of the support points. The element stresses and forces will be independent of any valid set of supports.

Rigid body vibration modes are calculated by a separate procedure provided that a set of free-body supports are supplied by the user. This is done to improve efficiency and, in some cases, reliability. The determinant method, for example, has difficulty extracting zero frequency roots of high multiplicity, whereas the alternate procedure of extracting rigid body modes is both efficient and reliable. If the user does not specify free-body supports (or he specifies an insufficient number of them) the (remaining) rigid body modes will be calculated by the method selected for the finite frequency modes, provided zero frequency is included in the range of interest. If the user does not provide free-body supports, and if zero frequency is not included in the range of interest, the rigid body modes will not be calculated.

Free-body supports must be specified if the mode acceleration method of solution improvement is used for dynamics problems having rigid body degrees of freedom (see Section 9.4 of the Theoretical Manual). This solution improvement technique involves a static solution, and although the dynamic solution can be made on a free-body, the static solution cannot be performed without removing the singularities in the stiffness matrix associated with the rigid body motions.

1.4.4 Partitioning

A two-way partitioning scheme is provided as an optional feature for the NASTRAN model. The partitions are defined by listing the degrees of freedom for one of the partitions on the ØMIT card. These degrees of freedom are referred to as the omitted set. The remaining degrees of freedom are referred to as the analysis set. The ØMIT1 Card is easier to use if a large number of grid points have the same degrees of freedom in the omitted set. The ASET or ASET1 cards can be used to place degrees of freedom in the analysis set with the remaining degrees of freedom being placed in the omitted set. This is easier if the omitted set is large. In the case of problems using conical shell elements, the ØMITAX card is used.

Partitioning can be used to improve the efficiency in the solution or ordinary statics problems where the bandwidth of the unpartitioned stiffness matrix is large enough to cause excessive use of secondary storage devices during the triangular decomposition of the stiffness matrix. In this application, the analysis set should be relatively small and should be selected so that the omitted set will consist of uncoupled partitions, each having a bandwidth of approximately the same size and smaller than the original matrix. The omitted set might be thought of as consisting of several substructures which are coupled to the analysis set.

Matrix partitioning also improves efficiency when solving a number of similar cases with stiffness changes in local regions of the structure. In this application, the omitted set is relatively large, and should be selected so that the structural elements that will be changed are connected only to points in the analysis set. The stiffness matrix for the omitted set is then unaffected by the structural changes, and only the smaller stiffness matrix for the analysis set need be decomposed for each case. In order to avoid repeating the decomposition of the stiffness matrix for the omitted set, the alter feature must be used to replace the functional module SMP1 with SMP2. The alter feature is described in Section 2.2, and a similar use of SMP2 occurs near the end of the DMAP sequence used in the rigid format for Static Analysis with Differential Stiffness.

CONSTRAINTS AND PARTITIONING

One of the more important applications of partitioning is the Guyan Reduction, described in Section 3.5.4 of the Theoretical Manual. This technique is a means for reducing the number of degrees of freedom used in dynamic analysis with minimum loss of accuracy. Its basis is that many fewer grid points are needed to describe the inertia of a structure than are needed to describe its elasticity with comparable accuracy. The error in the approximation is small provided that the set of displacements used for dynamic analysis is judiciously chosen. Its members should be uniformly dispersed throughout the structure and all large mass items should be connected to grid points that are members of the analysis set.

The user is cautioned to consider the fact that the matrix operations associated with this partitioning procedure tend to create nonzero terms and to fill what were previously very sparse matrices. The partitioning option is most effectively used if the members of the omitted set are either a very large fraction or a very small fraction of the total set. In most of the applications the omitted set is a large fraction of the total and the matrices used for analysis, while small, are usually full. If the analysis set is not a small fraction of the total, a solution using the larger, but sparser matrices, may well be more efficient. The partitioning option can also be used to make modest reductions in the order of the problem by placing a few scattered grid points in the omitted set. If the points in the omitted set are uncoupled, the sparseness in the matrices will be well preserved.

1.4.5 The Nested Vector Set Concept Used to Represent Components of Displacement

In constructing the matrices used in the Displacement Approach, each row and/or column of a matrix is associated closely with a grid point, a scalar point or an extra point. Every grid point has 6 degrees of freedom associated with it, and hence 6 rows and/or columns of the matrix. Scalar and extra points only have one degree of freedom. At each point (grid, scalar, extra) these degrees of freedom can be further classified into subsets, depending on the constraints or handling required for particular degrees of freedom. (For example, in a two-dimensional problem, all "z" degrees of freedom are constrained and hence belong to the s (single-point constraint) set). Each degree of freedom can be considered as a "point", and the entire model is the collection of these one-dimensional points.

Nearly all of the matrix operations in displacement analysis are concerned with partitioning, merging, and transforming matrix arrays from one subset of displacement components to another. All the components of displacement of a given type (such as all points constrained by single-point constraints) form a vector set that is distinguished by a subscript from other sets. A given component of displacement can belong to several vector sets. The mutually exclusive vector sets, the sum of whose members are the set of all physical components of displacements, are as follows:

- u_m points eliminated by multipoint constraints and rigid elements,
- u_s points eliminated by single-point constraints,
- u_o points omitted by structural matrix partitioning,
- u_r points to which determinate reactions are applied in static analysis,
- u_ℓ the remaining structural points used in static analysis (points left over),
- u_e extra degrees of freedom introduced in dynamic analysis to describe control systems, etc.

The vector sets obtained by combining two or more of the above sets are (+ sign indicates the union of two sets):

- $u_a = u_r + u_\ell$, the set used in real eigenvalue analysis,
- $u_d = u_a + u_e$, the set used in dynamic analysis by the direct method,
- $u_f = u_a + u_o$, unconstrained (free) structural points,
- $u_n = u_f + u_s$, all structural points not constrained by multipoint constraints,
- $u_g = u_n + u_m$, all structural (grid) points including scalar points,

$u_p = u_g + u_e$, all <u>physical</u> points.

In dynamic analysis, additional vector sets are obtained by a modal transformation derived from real eigenvalue analysis of the set u_a. These are:

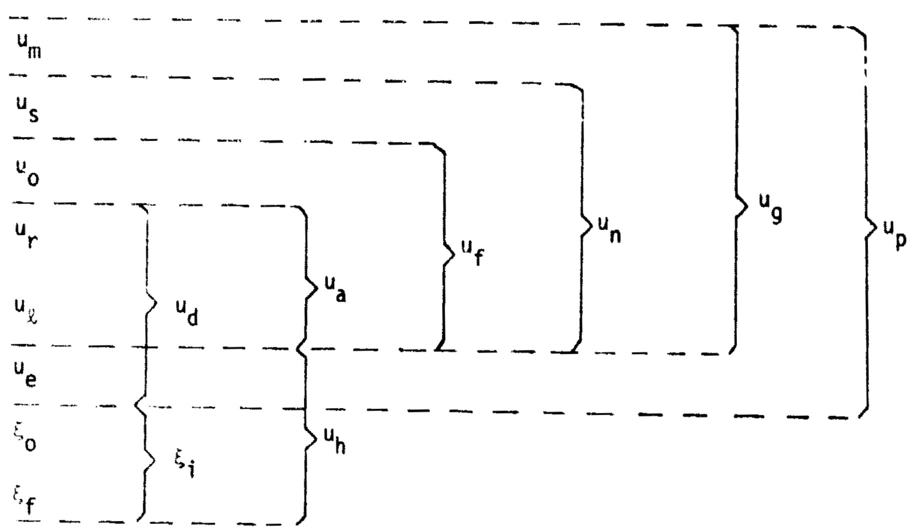
ξ_o rigid body (<u>zero</u> frequency) modal coordinates,

ξ_f <u>finite</u> frequency modal coordinates,

$\xi_i = \xi_o + \xi_f$, the set of all modal coordinates.

One vector set is defined that combines physical and modal coordinates. That set is $u_h = \xi_i + u_e$, the set used in dynamic analysis by the modal method.

The nesting of vector sets is depicted by the following diagram:



The data block USET (USETD in dynamics) is central to this set classification. Each word of USET corresponds to a degree of freedom in the problem. Each set is assigned a bit in the word. If a degree of freedom belongs to a given set, the corresponding bit is on. Every degree of freedom can then be classified by analysis of USET. The common block /BITPØS/ relates the sets to bit numbers. A table indicating the various sets to which each degree of freedom belongs may be obtained by setting DIAG 21 in the Executive Control Deck. This table provides a listing of each grid, scalar, and extra point in the model and shows the assignment of each associated degree of

freedom (six or one) to the sets L, A, F, N, G, R, Ø, S, and M. The S-set is further divided into the SB and SG "sub" sets to indicate constraints applied by SPC cards or GRID cards, respectively. Tables that indicate the membership of A-set, Ø-set, S-set, and M-set may be obtained by setting DIAG 22 in the Executive Control Deck. These tables summarize the degree of freedom assignments for sets M, S, Ø, and A. The S-set is further divided into the SPC and PERM SPC "sub" sets to indicate constraints applied by SPC cards or GRID cards, respectively.

In constructing the matrices used in the Heat Approach, the user must constrain five of the six degrees of freedom associated with each grid point. Since the only unknown at a grid point is its temperature, there is only one degree of freedom per grid point.

In constructing the matrices used in the Aero Approach, the aerodynamic degrees of freedom (including extra points) are added after the structural matrices have been determined. This introduces the following displacement sets:

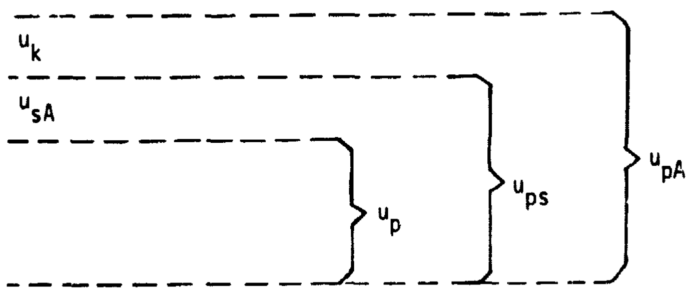
u_k aerodynamic box and body degrees of freedom

u_{sA} permanently constrained degrees of freedom associated with aerodynamic grid points

u_{ps} the union of u_p and u_{sA}

u_{pA} the union of u_k and u_{ps}

The nesting of the vector sets in the Aero Approach is indicated below:



The u_{pA} set replaces the u_p set for output at grid, scalar, and extra points.

the decomposition of the stiffness matrix when changes are only made in the magnitudes of the enforced displacements.

The equivalent loads resulting from enforced displacments of grid points are calculated by the program and added to the other applied loads. The magnitudes of the enforced displacements are specified on SPC cards (SPCAX in the case of conical shell problems) in the global coordinate system. The application of the load is automatic when the user selects the associated SPC set in the Case Control Deck.

The LØAD card in the Bulk Data Deck defines a static loading condition that is a linear combination of load sets consisting of loads applied directly to grid points, pressure loads, gravity loads and centrifugal forces. This card must be used if gravity loads are to be used in combination with loads applied directly to grid points, pressure loads or centrifugal forces. The application of the combined loading condition is requested in the Case Control Deck by selecting the set number of the LØAD combination.

It should be noted that the equivalent loads (thermal, enforced deformation and enforced displacement) must have unique set identification numbers and be seperately selected in the Case Control Deck. For any particular solution, the total static load will be the sum of the applied loads (grid point loading, pressure loading, gravity loading and centrifugal forces) and the equivalent loads.

1.5.2 Frequency Dependent Loads

A discussion of frequency response calculations is given in Section 12.1 of the Theoretical Manual. The DLØAD card is used to define linear combinations of frequency dependent loads that are defined on RLØAD1 or RLØAD2 cards. The RLØAD1 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{A[C(f) + iD(f)]e^{i(\theta-2\pi f\tau)}\right\}, \tag{1}$$

where A is defined on a DAREA card, C(f) and D(f) are defined on TABLEDi cards, θ is defined on a DPHASE card and τ is defined on a DELAY card. The RLØAD2 card defines a frequency dependent load of the form

$$\{P(f)\} = \left\{AB(f)e^{i\{\phi(f)+\theta-2\pi f\tau\}}\right\}, \tag{2}$$

where A is defined on a DAREA card, B(f) and ϕ(f) are defined on TABLEDi cards, θ is defined on a

DPHASE card, and τ is defined on a DELAY card. The coefficients on the DAREA, DELAY and DPHASE cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

A discussion of random response calculations is given in Section 12.2 of the Theoretical Manual. The RANDPS card defines load set power spectral density factors for use in random analysis of the form

$$S_{jk}(f) = (X + iY)G(f) \quad , \qquad (3)$$

where G(f) is defined on a TABRNDi card. The subscripts j and k define the subcase numbers of the load definitions. If the applied loads are independent, only the diagonal terms (j=k) need be defined. The RANDT1 card is used to specify the time lag constants for use in the computation of the autocorrelation functions.

1.5.3 Time Dependent Loads

A discussion of transient response calculations is given in Section 11 of the Theoretical Manual. The DLØAD card is used to define linear combinations of time dependent loads that are defined on TLØAD1 and TLØAD2 cards. The TLØAD1 card defines a time dependent load of the form

$$\{P(t)\} = \{AF(t - \tau)\} \quad , \qquad (4)$$

where A is defined on a DAREA card, τ is defined on a DELAY card, and $F(t-\tau)$ is defined on a TABLEDi card. The TLØAD2 card defines a time dependent load of the form

$$\{P(t)\} = \begin{cases} \{0\} , & \tilde{t} < 0 \text{ or } \tilde{t} > T_2 - T_1 \\ \left\{A\tilde{t}^B e^{C\tilde{t}} \cos(2\pi f\tilde{t}+P)\right\}, & 0 \le \tilde{t} \le T_2 - T_1 \end{cases} \quad , \qquad (5)$$

where $\tilde{t} = t - T_1 - \tau$ and A and τ are defined as above. The coefficients on the DAREA and DELAY cards may be different for each loaded degree of freedom. The loads are applied to the specified components in the global coordinate system.

Nonlinear effects are treated as an additional applied load vector, for which the components are functions of either displacements or velocities. This additional load vector is added to the right side of the equations of motion and treated along with the applied load vector during

numerical integration. It is required that the points to which the nonlinear loads are applied and the degrees of freedom on which they depend be members of the solution set, i.e., that they cannot be degrees of freedom eliminated by constraints. It is further required, that if a modal formulation is used, the points referenced by the nonlinear loads be members of the set of extra scalar points introduced for dynamic analysis.

At present, NASTRAN includes four different types of nonlinear elements. For a discussion of nonlinear elements see Section 11.2 of the Theoretical Manual. The NØLIN1 card defines a nonlinear load of the form

$$P_i(t) = S_i T(x_j) \quad , \tag{6}$$

where P_i is the load applied to x_i, S_i is a scale factor, $T(x_j)$ is a tabulated function defined with a TABLEDi card, and x_j is any permissible displacement or velocity component. The NØLIN2 card defines a nonlinear load of the form

$$P_i(t) = S_i \, x_j \, y_k \quad , \tag{7}$$

where x_j and y_k are any permissible pair of displacement or velocity components. They may be the same. The NØLIN3 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} S_i(x_j)^A \; , & x_j > 0 \\ 0 \; , & x_j \le 0 \end{cases} \quad , \tag{8}$$

where A is an exponent. The NØLIN4 card defines a nonlinear load of the form

$$P_i(t) = \begin{cases} -S_i(-x_j)^A \; , & x_j < 0 \\ 0 \; , & x_j \ge 0 \end{cases} \quad . \tag{9}$$

Nonlinear loads applied to a massless system without damping will not converge to a steady state solution. Use of DIAG 10 (Section 2.2.1) will cause the nonlinear term $\{N_{n+1}\}$ to be replaced by 1/3 $\{N_{n+1} + N_n + N_{n-1}\}$ where N_{n+1}, N_n and N_{n-1} are the values of the nonlinear loads at time steps preceding the solution time step. Section 11.3 of the Theoretical Manual discusses the integration equations.

1.8 HEAT TRANSFER PROBLEMS

1.8.1 Introduction to NASTRAN Heat Transfer

NASTRAN heat flow capability may be used either as a separate analysis to determine temperatures and fluxes, or to determine temperature inputs for structural problems. Steady and transient problems can be solved, including heat conduction (with variable conductivity for static analysis), film heat transfer, and nonlinear (fourth power law) radiation.

The heat flow problem is similar, in many ways, to structural analysis (Figure 1). The same grid points, coordinate systems, elements, constraints, and sequencing can be used for both problems. There are several differences, such as the number of degrees of freedom per grid point, the methods of specifying loads, boundary film heat conduction, and the nonlinear elements. For heat flow problems, the only unknown at a grid point is the temperature (cf. structural analysis with three translations and three rotations), and hence, there is one degree of freedom per grid point. Additional grid or scalar points are introduced for fluid ambient temperatures in convective film heat transfer. If radiation effects are included or the conductivity of an element is temperature dependent, the problem becomes nonlinear (cf. structural analysis with temperature dependent materials which only requires looking up material properties and computing thermal loads).

The heat conduction analysis of NASTRAN is compatible with structural analysis. If the same finite elements are appropriate, then the same grid and connection cards can be used for both problems. As in structural analysis, the choice of a finite element model is left to the analyst. Temperature distributions can be output in a format which can be input into structural problems. Heat flow analysis uses many structural NASTRAN Bulk Data cards. These include (where i means there is more than one type): CBAR, CDAMPi, CELASi, CHEXAi, CIHEXi, CØNRØD, CØRDii, CQDMEM, CQDPLT, CQUADi, CRØD, CTETRA, CTRAPRG, CTRIAi, CTRIARG, CTRMEM, CTUBE, CVISC, CWEDGE, DAREA, DELAY, DLØAD, DMI, DMIG, EPØINT, GRDSET, GRID, LØAD, MPC, MPCADD, NØLINi, ØMITi, PARAM, Piii (for elements requiring properties), PLØTEL, SEQiP, SLØAD, SPCi, SPCADD, SPØINT, TABLEDi, TABLEMi, TEMPii, TF, TLØADi, and TSTEP.

1.8.2 Heat Transfer Elements

The basic heat conduction elements are the same as NASTRAN structural elements. These elements are shown in the following table:

Heat Conduction Elements	
Type	**Elements**
Linear	BAR, RØD, CØNRØD, TUBE
Membrane	TRMEM, TRIA1, TRIA2, QDMEM, QUAD1, QUAD2
Solid of Revolution	TRIARG, TRAPRG
Solid	TETRA, WEDGE, HEXA1, HEXA2, IHEX1, IHEX2, IHEX3
Scalar	CELASi, CDMAPi

A connection card (Cxxx) and, if applicable, a property card (Pxxx) is defined for each of these elements. Linear elements have a constant cross-sectional area. The offset on the BAR is treated as a perfect conductor (no temperature drop). For the membrane elements, the heat conduction thickness is the membrane thickness. The bending characteristics of the elements do not enter into heat conduction problems. The solid of revolution element, TRAPRG, has been generalized to accept general quadrilateral rings (i.e., the top and bottom need not be perpendicular to the z-axis for heat conduction). These heat conduction elements are composed of constant gradient lines, triangles, and tetrahedra. The quadrilaterals are composed of overlapping triangles, and the wedges and hexahedra from subtetrahedra. Scalar spring elements are used for transient analysis temperature constraints and scalar damping elements are used to add thermal mass. Gradients and fluxes may be output by requesting ELFØRCE.

Thermal material conductivities and heat capacities are given on MAT4 (isotropic) and MAT5 (anisotropic) Bulk Data cards. Temperature dependent conductivities are given on MATT4 and MATT5 bulk data cards, which can only be used for nonlinear static analysis. The heat capacity per unit volume is specified, which is the product of density and heat capacity per unit mass (ρC_p). Lumped conductivities and thermal capacitance may be defined by the CELASi and CDAMPi elements, respectively.

A special element (HBDY) defines an area for boundary conditions. There are five basic types, called PØINT, LINE, REV, AREA3, and AREA4. A sixth type, ELCYL, is for use only with QVECT radiation. The HBDY is considered an element, since it can add terms to the conduction and heat capacity matrices. There is a CHBDY connection and PHBDY property card. When a film heat transfer condition is desired, film conductivity and heat capacity per unit area are specified on MAT4 data cards. The ambient temperature is specified with additional points (GRID or SPØINT) listed on the CHBDY connection card. See Figure 2 for geometry.

Radiation heat exchange may be included between HBDY elements. A list of HBDY elements must be specified on a RADLST Bulk Data card. The emissivities are specified on the PHBDY cards. The Stefan-Boltzmann constant (SIGMA) and absolute reference temperature (TABS) are specified on PARAM Bulk Data cards. Radiation exchange coefficients (default is zero) are specified on RADMTX Bulk Data cards.

The several types of power input to the HBDY elements can be output by the ELFØRCE request.

1.8.3 Constraints and Partitioning

Constraints are applied to provide boundary conditions, represent "perfect" conductors, and provide other desired characteristics for the heat transfer model.

Single point constraints are used to specify the temperature at a point. The grid or scalar points are listed on SPC or SPC1 bulk data cards, not GRDSET or GRID cards. The component on the data card must be "0" or "1". This declares the degree of freedom to be in the u_s set. The method of specifying temperature is dependent upon the problem type.

In linear statics analysis, the SPC or SPC1 card is used to constrain grid points at a fixed temperature. In nonlinear statics analysis, the SPC or SPC1 card is used to designate the grid point ID which is to be constrained. The actual value of the temperature is indicated on a TEMP card, selected by TEMP(MATERIAL) in the Case Control deck. In transient analysis, the SPC or SPC1 card may be used to fix the temperature of a grid point only when the temperature is zero. When the temperature is non-zero a large conductive coupling to a "ground" at absolute temperature must be defined. From the structural relationship F=Kx, the thermal analogy is made where K is the conductive coupling, F is an applied load, and x is the fixed temperature. In this case, x is adjusted to the desired temperature by defining the spring constant, K, of a CELAS1 element, which

is connected to "ground", and a load, F, which is applied to the grid point in question. The numerical value of K should be several orders of magnitude greater than the numerical value of the conductances prescribed for the rest of the model.

Multipoint constraints are linear relationships between temperatures at several grid points, and are specified on MPC cards. The first entry on an MPC card will be in the u_m set. The type of constraint is limited if nonlinear elements are present. If a member of set u_m touches a nonlinear (conduction or radiation) element, the constraint relationship is restricted to be an "equivalence". The term "equivalence" means that the value of the member of the u_m set will be equal to one of the members of the u_n set (a point not multipoint constrained). Those points not touching nonlinear elements are not so limited. The user will be responsible to satisfy the equivalence requirement, by having only two entries on the MPC data card, with equal (but opposite in sign) coefficients.

1.8.4 Thermal Loads

Thermal "loads" may be boundary heat fluxes or volume heat addition. As in the case of structural analysis, the method of specifying loads is different for static and transient analysis. The HBDY element is used for boundaries of conducting regions. Surface heat flux input can be specified for HBDY elements with QBDY1 and QBDY2 data cards. These two cards are for constant and (spatially) variable flux, respectively. Flux can be specified without reference to an HBDY elemen with the QHBDY data card. Vector flux, such as solar radiation, depends upon the angle between the flux and the element normal, and is specified for HBDY elements with the QVECT data card. This requires that the orientation of the HBDY element be defined. Volume heat addition into a conduction element is specified on a QVØL data card.

Static thermal loads are requested in Case Control with LØAD card. All of the above load types plus SLØAD's can be requested. Transient loads are requested in Case Control with a DLØAD card, which selects TLØAD time functions. Transient thermal loads may use DAREA (as in structural transient), and/or the QBDY1, QBDY2, QHBDY, QVECT, QVØL, and SLØAD cards. The resultant thermal load will be the sum of all loads applied. This means the LØAD SIDs and DAREA SIDs must be the same when referenced on a TLØADi card.

1.8.5 Linear Static Analysis

Linear static analysis uses APProach HEAT, SOLution 1. The rigid format is the same as that used for static structural analysis. This implies that several loading conditions and constraint

sets can be solved in one job, by using subcases in the Case Control deck.

1.8.6 Nonlinear Static Analysis

Nonlinear static analysis uses APProach HEAT, SØLution 3. This rigid format will allow temperature dependent conductivities of the elements, nonlinear radiation exchange, and a limited use of multipoint constraints. There is no looping for load and constraints. The solution is iterative. The user can supply values on PARAM Bulk Data cards for:

MAXIT (integer)	Maximum number of iterations (default 4).
EPSHT (real)	ε convergence parameter (default .001).
TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
IRES (integer)	Request residual vector output if positive (default -1).

The user must supply an estimate of the temperature distribution vector $\{u^1\}$. This estimate is used to calculate the reference conductivity plus radiation matrix needed for the iteration. $\{u^1\}$ is also used at all points in the u_s set to specify a boundary temperature. The values of $\{u^1\}$ are given on TEMP Bulk Data cards, and they are selected by TEMP(MATERIAL) in Case Control.

Iteration may stop for the following reasons:

1. Normal convergency: $\varepsilon_T < $ EPSHT, where ε_T is the per unit error estimate of the temperatures calculated.
2. Number of iterations > MAXIT.
3. Unstable: $|\lambda_1| < 1$ and the number of iterations > 3, where λ_1 is a stability estimator.
4. Insufficient time to perform another iteration and output data.

The precise definitions are given in the NASTRAN Theoretical Manual, Section 8.4. Error estimates ε_p, λ_1, and ε_T for all iterations may be output with the Executive Control card DIAG 18, where ε_p is the ratio of the Euclidian norms of the residual (error) loads to the applied loads on the unconstrained degrees of freedom.

1.8.7 Transient Analysis

Transient analysis uses APProach HEAT, SØLution 9. This rigid format may include conduction, film heat transfer, nonlinear radiation, and NASTRAN nonlinear elements. Extra points are used as

in structural transient analysis. All points associated with nonlinear loads must be in the solution set. Loads may be applied with TLØAD and DAREA cards as in structural analysis. Also, the thermal static load cards can be modified by a function of time for use in transient analysis. If the static load data is used to define a transient load, the static load set identification is referenced on the TLØAD card in the DAREA field. Loads are requested in Case Control with DLØAD. Initial temperatures are specified on TEMP Bulk Data cards and are requested by IC. Previous static or transient solutions can be easily used as initial conditions, since they can be punched in the correct format. An estimate of the temperature $\{u^1\}$ is specified on TEMP Bulk Data cards for transient with radiation, and is requesed by TEMP(MATERIAL). The parameters available are:

TABS (real)	Absolute reference temperature (default 0.0).
SIGMA (real)	Stefan-Boltzmann radiation constant (default 0.0).
BETA (real)	Foreward difference integration factor (default .55).
RADLIN (integer)	Radiation is linearized if positive (default -1).

Time steps are specified on TSTEP data cards.

1.8.8 Compatibility with Structural Analysis

Grid point temperatures for thermal stress analysis (static structural analysis) are specified on TEMP Bulk Data cards. If punched output is requested in a heat conduction analysis for Rigid Formats 1 and 3, the format of the punched card is exactly that of a double field TEMP* data card. Thus, if the heat conduction model is the same as the structural model, the same grid, connection, and property cards can be used for both, and the temperature cards for the structural analysis are produced by the heat conduction analysis. The output request in Case Control is THERMAL(PUNCH).

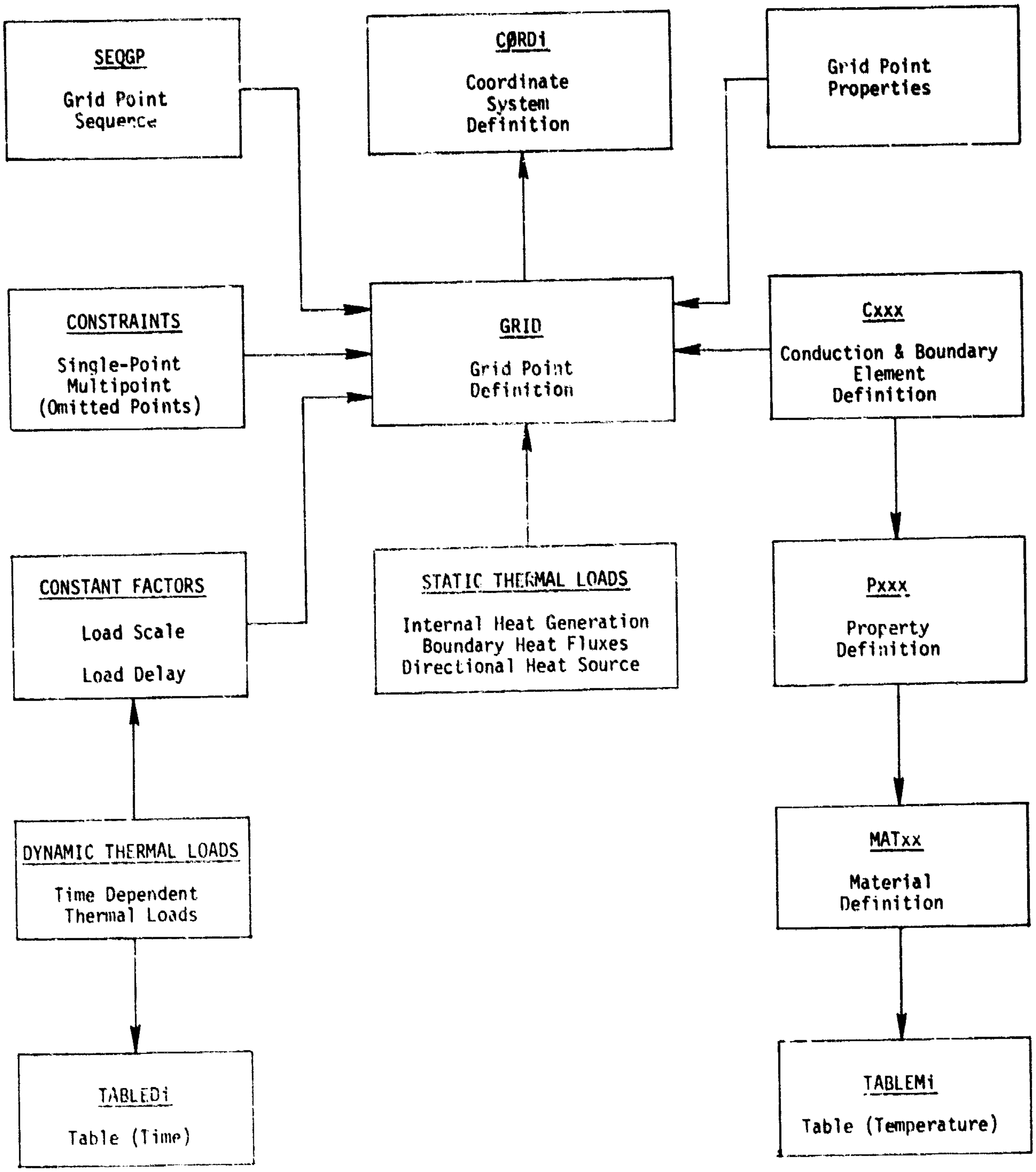
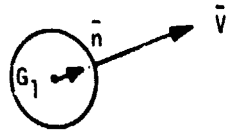


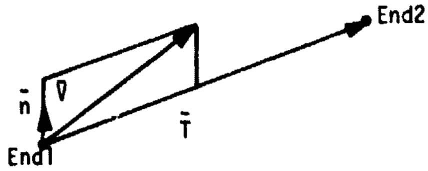
Figure 1. Thermal model diagram.

Type = PØINT



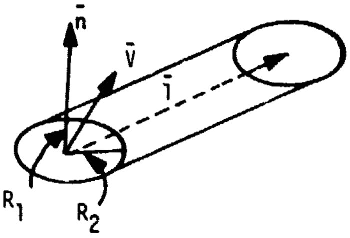
The unit normal vector is given by $\bar{n} = \bar{V}/|\bar{V}|$, where $\bar{V}$ is given in the basic system at the referenced grid point (see CHBDY data card, fields 16-18).

Type = LINE



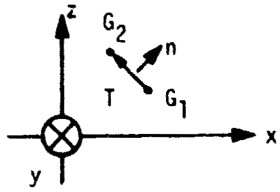
The unit normal lies in the plane of $\bar{V}$ and $\bar{T}$, is perpendicular to $\bar{T}$, and is given by $\bar{n} = (\bar{T} \times (\bar{V} \times \bar{T}))/|\bar{T} \times (\bar{V} \times \bar{T})|$.

Type = ELCYL



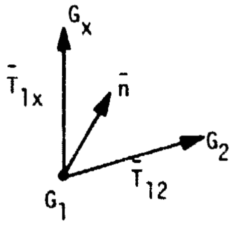
The same logic is used to determine $\bar{n}$ as for type = LINE. The "radius" R_1 is in the $\bar{n}$ direction, and R_2 is perpendicular to $\bar{n}$ and $\bar{T}$ (see fields 7 and 8 of PHBDY card).

Type = REV



The unit normal lies in the x-z plane, and is given by $\bar{n} = (\bar{e}_y \times \bar{T})/|\bar{e}_y \times \bar{T}|$. $\bar{e}_y$ is the unit vector in the y direction.

Type = AREA3 or AREA4



The unit normal vector is given by $\bar{n} = (\bar{T}_{12} \times \bar{T}_{1x})/|\bar{T}_{12} \times \bar{T}_{1x}|$, where x = 3 for triangles and x = 4 for quadrilaterals.

Figure 2. HBDY Element Orientation (for QVECT flux).

1.10 SUBSTRUCTURING

Substructuring is an analytical technique used to facilitate the solution of structural problems by subdividing the structural models into smaller, more manageable components. The most elementary component, or basic substructure, is modeled separately just as any finite element model would be. These basic substructures are combined to build more complex substructures which, in turn, can be progressively combined with other substructures in stages to eventually arrive at the final desired solution model. Once the solution model is analyzed, the results at each stage of the combination process may be recovered until, ultimately, the detailed solution data are recovered for each of the original basic substructures. In effect, substructuring is an extension of basic finite element theory itself whereby the usual simple beam, plate, and solid elements are replaced by basic substructures which themselves may be viewed as components of even more complex substructures.

Substructure analysis is logically performed in at least three phases as follows:

Phase 1 - Analysis of each individual substructure by NASTRAN to produce a description, in matrix terms, of its properties as seen at the boundary degrees of freedom, u_a.

Phase 2 - Combination of the matrix properties from Phase 1 and the inclusion, if desired, of additional terms to form a "pseudostructure," which is then analyzed by NASTRAN.

Phase 3 - Completion of the analysis of individual substructures using the $\{u_a\}$ vector produced in Phase 2.

To provide maximum program flexibility, both the manual and automated approaches to substructuring are available. The manual approach requires user-generated DMAP alters and can be used in all Rigid Formats except for Piecewise Linear Analysis. The procedures for single-stage, manual substructuring are discussed and illustrated with a complete and fully annotated example of the input in Section 1.10.1. In Section 1.10.2, the automated multi-stage substructuring capabilities available for Rigid Formats 1, 2, and 3 are presented, also with a complete and annotated example.

Unlike the manual substructuring procedures, the automated capabilities provide for:

1. Simple commands to control execution and data recovery at all stages of analysis.
2. Automatically generated DMAP alters.
3. Automated procedures to control and maintain the extensive data files required.
4. Data storage on single direct access file (minimizes or eliminates checkpoint/restart tapes).
5. Data transfer among IBM, CDC, or UNIVAC computers at any stage in the analysis.

6. No restrictions on grid point and element numbering.
7. Modeling only one of two or more identical substructure components.

It should be noted that cyclic symmetry is available as an alternate formulation for substructuring structures with rotational or dihedral symmetry. This capability is described in Section 1.12. The more general approaches are described below starting with the manual, single-stage substructuring, followed by the automated multi-stage substructuring capabilities.

1.10.1. Manual Single-Stage Substructuring

The theoretical basis for NASTRAN manual substructuring is given in Section 4.3 of the Theoretical Manual. This technique may be used with any of the rigid formats, except Piecewise Linear Analysis. The following sections present instructions, including Series Ø DMAP alters for use with two of the rigid formats, Static Analysis and Normal Modes Analysis.

Manual substructure analysis, as here defined, is a procedure in which the structural model is divided into separate parts which are then processed in separate computer executions to the point where the data blocks required to join each part to the whole are generated. The subsequent operations of merging the data for the substructures and of obtaining solutions for the combined problem are performed in one or more subsequent executions, after which detailed information for each substructure is obtained by additional separate executions.

The NASTRAN Data Deck for each of the substructures is constructed in the same manner as a NASTRAN analysis without substructuring. The following restrictions must be considered when forming the NASTRAN Data Deck for each of the substructures:

1. All points on boundaries between substructures which are to be joined must have their free (unconstrained) degrees of freedom placed in the a-set.
2. The sequence of internal grid point identification numbers along the boundary between any two substructures must be in the same order. The internal sequence is the external sequence modified by any SEQGP cards. For example, if one substructure had boundary grid point internal identification numbers of 3, 4, 9, 27, and 31, the adjoining substructure could have a corresponding set of internal grid point identification numbers of 7, 11, 21, 22, and 41, but not 7, 11, 22, 21, and 41. This restriction is automatically satisfied if the same grid point numbers, without SEQGP cards, are used on the boundaries for connected substructures.

3. The displacement coordinate system for each group of connected grid points on the boundaries between substructures must be the same.

4. Elements located on the boundary may be placed in either adjacent substructure.

5. The loads applied to boundary points may be arbitrarily distributed between the adjoining substructures. Care should be exercised not to duplicate the loads by placing the entire load on each substructure.

6. The constrained stiffness matrix, $[K_{oo}]$, for each substructure must be nonsingular. This requirement is automatically satisfied in most cases, since usually there are enough degrees of freedom on the boundary of the substructure to account for its rigid body motions. In exceptional cases, such as when the substructure is a hinged appendage, it may be necessary for the user to assign additional degrees of freedom to u_a, rather than u_o via ASET cards.

Although the following discussion is limited to single-stage substructuring, there is no inherent restriction on the use of multi-stage substructures in NASTRAN. In multi-stage substructuring, some of the substructures are precombined in Phase 2 to form intermediate substructures. The final combination in Phase 2 then consists of joining two or more intermediate substructures. This procedure will be useful if there are several substructures in the model, and changes are made in only one or a few substructures. In this case, the amount of effort and computer time required for changes in the model can be substantially reduced if the unchanged substructures are initially combined into a single intermediate substructure.

1.10.1.1 Basic Manual Substructure Analysis

Basic manual substructure analysis will be described with reference to the simple beam structure shown in Figure 1. The beam is arbitrarily separated into two substructures, referred to as substructure 1 and substructure 2, with a single boundary point being located at grid point 3. The beam is supported at grid points 1 and 6. No loads are applied to substructure 1. A single load is applied to substructure 2 at grid point 4, and a single load is applied at the boundary to grid point 3.

The complete NASTRAN Data Decks for all three phases of a substructure analysis for the beam shown in Figure 1 are presented in Tables 1, 3, 5, 7, and 9. The integers in the left-hand column are used to relate the respective discussions in Tables 2, 4, 6, 8, and 10 to the cards in the NASTRAN Data Decks.

It should be noted that no output has been requested in the Case Control Deck for substructure 1. If the user wishes to have a plot of the undeformed structure for checking the model, a Plot Package can be inserted in the Case Control Deck in the usual way, as described in Section 4.2.

The partitioning matrix gives the relationship between the internal indices associated with the a-set matrices generated in Phase 1 and the external grid point component definition given on the GRID cards that are input to Phase 1 as modified by any SEQGP cards. The same internal indices in Phase 1 for the a-set are redefined in Phase 2 as the indices for the g-set. The word "pseudostructure" is associated with the g-size matrices used in Phase 2.

The partitioning matrix for the problem under consideration is given as follows:

PARTITIONING MATRIX

	External Grid-Component	
Internal Index	Substructure 1	Substructure 2
1	3-1	3-1
2	3-2	3-2
3	3-6	3-6

The procedure for constructing a partitioning matrix is as follows:

1. Select any one of the substructures and list the components of the a-set in sequence by grid point and component number as modified by any SEQGP cards (internal sequence). These are the nonzero entries in the partitioning vector for the first substructure.

2. Build the second column of the partitioning matrix by selecting any connected substructure and entering the connected components in the same row as the associated components in the first substructure.

3. Enter all unconnected a-set components in unoccupied rows of the partitioning matrix according to their internal sequence numbers. Unconnected members of the a-set having internal sequence numbers in the range of the connected components will create new intermediate rows in the previously formed columns of the matrix.

4. Build the remaining columns of the partitioning matrix, one for each substructure, by following a similar procedure for all remaining substructures. In each case, first enter all components that are connected to the previously selected substructure or

substructures, followed by the remaining unconnected components in their internal sequence.

5. The rows of the partitioning matrix are associated with the sequence of the internal indices for the scalar points in the pseudostructure. Any sequential set of integers may be used to identify these scalar points in Phase 2.

6. The columns of the partitioning matrix (one vector for each substructure) are input with Direct Matrix Input (DMI) cards. The input matrix contains real 1's in all locations in the partitioning matrix having grid point-component entries. See Section 2.4 for DMI card format.

The DMI cards (121 and 122 in Table 1) in the sample problem give the name E1 to the partitioning vector for substructure 1. The first card defines the partitioning vector as being rectangular and consisting of real single-precision entries. The next to the last entry on the first card indicates there are three rows in the g-set matrices input to Phase 2. The second integer 1 on the second card indicates that the first internal index is associated with one of the components in substructure 1; in this case, grid point 3, component 1. The three real 1.0's indicate the first three internal indices are associated with components in substructure 1; in this case, grid point 3, components 1, 2, and 6. In this particular case, only the initial two steps are required to construct the partitioning matrix and the partitioning vector for substructure 2 will be identical to that for substructure 1. This results from the fact that the single boundary point in this problem is a part of both substructures.

The partitioning vectors are not needed until Phase 2. They were arbitrarily input to Phase 1 so they could be included on the User Tape, along with the output matrices from Phase 1.

The NASTRAN Data Deck for substructure 2 is given in Table 3. For identification purposes, the cards are arbitrarily numbered beginning with 150.

The Phase 2 operations are concerned with merging the a-set matrices generated in Phase 1 which define the g-size pseudostructure in Phase 2. The NASTRAN Data Deck for Phase 2 is given in Table 5. The cards are arbitrarily numbered beginning with 201.

Although the data deck shown in Table 5 is prepared for two substructures, it was constructed in such a manner that it could be easily extended to more than two substructures. If there are more than two substructures, cards similar to 216 to 222, 232, and 233 need to be added to the NASTRAN data deck for each additional substructure.

The final part of a substructure analysis is to perform data recovery for each substructure of interest. These runs are made as a restart of the Phase 1 runs. Any of the normal rigid format output can be requested, including both undeformed and deformed structure plots. All of the output will be in terms of the elements and grid points defined in the Phase 1 Bulk Data Decks. The NASTRAN Data Deck for the Phase 3 analysis of substructure 1 is given in Table 7.

The NASTRAN data deck for the Phase 3 analysis of substructure 2 is given in Table 9. Comments are restricted to cards that are different from those presented for the Phase 3 run of substructure 1.

1.10.1.2 Loads and Boundary Conditions

The single load and the single boundary condition for the sample problem defined in Section 1.10.1.1 were introduced in Phase 1. It is also possible to introduce loads and boundary conditions in Phase 2. In this case, the loaded and/or constrained degrees of freedom must be included in the a-set for Phase 1, so they will be a part of the pseudostructure in Phase 2. Loads are applied to the pseudostructure in Phase 2 with the SLØAD card. This limits the type of load that can be applied in Phase 2 to directly applied loads. Other loading conditions depending on element properties or connection data, such as thermal loads, gravity loads, and pressure loads, must be applied in Phase 1. Loads may be introduced in both Phases 1 and 2, as the suggested DMAP sequence will add contributions to the load vector from both phases. The lack of generality for the application of loads in Phase 2 will often dictate that static loads be applied in Phase 1.

The loads and boundary conditions for the sample problem can be applied in Phase 2 if the modifications shown in Tables 11 and 12 are made to the NASTRAN Data Decks presented in Section 1.10.1.1.

The modified partitioning matrix with grid points 1, 3, 4, and 6 in the a-set is shown below.

PARTITIONING MATRIX

	External Grid-Component	
Internal Index	Substructure 1	Substructure 2
1	1-1	
2	1-2	
3	1-6	
4	3-1	3-1
5	3-2	3-2
6	3-6	3-6
7		4-1
8		4-2
9		4-6
10		6-1
11		6-2
12		6-6

The modified partitioning matrix contains twelve scalar points, with six in substructure 1, nine in substructure 2, and three common to both substructures. The loads are now located at scalar points 5 and 8, as indicated on card 24Ca. The single-point constraints are located at scalar points 1, 2, and 11, as indicated on card 246b. The modified partitioning vector for substructure 1 indicates there are twelve degrees of freedom in the pseudostructure, and that, beginning with the first scalar point, there are six scalar points associated with substructure 1. The modified partitioning vector for substructure 2 indicates the first entry is associated with scalar point 4, and that there are a total of nine scalar points associated with substructure 2.

If multiple loading conditions are used in the solution, the subcase structure must be established in Phase 1. In order to perform the matrix operations in Phase 2, the same case control structure must be used for all substructures. This means that the same number of subcases must be defined for each substructure, even though some of the subcases will not contain a load selection or any other entries. NASTRAN will generate a null column in the load matrix for all subcases for which no load set is selected. If any loads are applied in Phase 2, the

same subcase structure must be used in Phase 2. In any event, the subcase structure established in Phase 1 must be used in Phase 3. The contents of each subcase in Phase 3 will relate to output selections, rather than load and boundary condition selections.

Consider adding two additional loading conditions to the sample problem in Section 1.10.1.1. If one additional loading condition were applied to substructure 1, identified as 202, and one additional loading to substructure 2, identified as 203, the subcase structure established in Phase 1 would appear as follows:

Substructure 1	Substructure 2
SPC = 101	SPC = 201
SUBCASE 1	SUBCASE 1
	LØAD = 201
SUBCASE 2	SUBCASE 2
LØAD = 202	
SUBCASE 3	SUBCASE 3
	LØAD = 203

Load case 202 would have to be defined with some form of static loading in the Bulk Data Deck for Phase 1 of substructure 1. In addition, load set 203 would have to be defined with some form of static loading in the Bulk Data Deck for Phase 1 of substructure 2.

The DMAP sequence for the sample problem in Section 1.10.1.1 will not support multiple boundary conditions in Phase 1. If multiple boundary conditions are introduced in Phase 1, it is necessary to generate a separate partitioning vector for use in Phase 2 for each of the unique boundary conditions. In some sense, this results in the definition of a number of separate problems equal to the number of unique boundary conditions. Although a DMAP sequence could be developed to support multiple boundary conditions in Phase 1, it is not recommended that multiple boundary conditions be introduced into Phase 1.

Multiple boundary conditions may be introduced in Phase 2 without any difficulty. However, in order to handle the internal looping for each boundary condition, it is more convenient if the loads are also introduced in Phase 2. As indicated earlier, the introduction of loads in Phase 2 does limit the manner in which the static loads can be defined. If the

loads and boundary conditions are introduced in Phase 2, all of the case control options for combining subcases, including symmetry combinations, may be used in the usual manner.

It is possible to introduce the loads in Phase 1 and multiple boundary conditions in Phase 2. However, provision must be made to generate all loading conditions in Phase 1, which will automatically take place if one subcase is defined for each loading condition and no boundary conditions are mentioned in the Phase 1 Case Control Deck. It is then necessary in Phase 2 to partition out the proper columns of the loading matrix for each loop or boundary condition in Phase 2. This requires that the user construct the proper partitioning vector for each boundary condition. Also, appropriate modifications would have to be made to the suggested DMAP sequence for Phase 2.

1.10.1.3 Normal Modes Analysis

Substructuring for normal modes analysis is performed in much the same way as that for static analysis. A NASTRAN Data Deck for use in Phase 1 of a Normal Modes Analysis (Rigid Format 3) is shown in Table 13.

Note that the ØUTPUT1 module writes the mass matrix, as well as the stiffness matrix and partitioning vector on User Tape 1. The Case Control Deck is similar to the Phase 1 deck for static analysis. It must include a constraint selection if the boundary conditions are applied in Phase 1. The Bulk Data Deck is also similar to that used in Phase 1 for static analysis. In general, it includes all the cards associated with the definition of the model and the DMI cards for the definition of the partitioning vector. It will also include cards for the definition of the a-set and other constraint cards if the boundary conditions are applied in Phase 1. As in static analysis, one such deck must be prepared for each substructure.

The NASTRAN Data Deck for Phase 2 of Normal Modes Analysis with two substructures is shown in Table 14.

The Phase 2 NASTRAN Data Deck for Normal Modes Analysis is similar to that used for Static Analysis. The following comments are related to differences in the two decks:

1. Since there are no loads associated with a normal modes analysis, the module GP3 is not executed.
2. The same operations are performed on the mass matrix as are performed for the stiffness matrix.

3. The data block LAMA (Eigenvalue Summary) is written as the first data block on User Tape 3. This is followed by the appropriate partitions of the eigenvectors for each of the substructures.

4. The Case Control Deck must include a method selection for eigenvalue extraction.

5. The Bulk Data Deck is similar to that used in static analysis, except that a null matrix must be defined for the mass matrix, instead of the load matrix (since matrix assembly is not required), and an EIGR card must be included.

The Phase 3 data deck for Normal Modes Analysis, given in Table 15, is similar to that used for Static Analysis. The first reference to module INPUTT1 is to read the data block LAMA, which is the first data block on User Tape 3. The second reference to INPUTT1 is to read the proper partition of the eigenvectors. The zero parameter at the end of the statement should be incremented one for each substructure in order to point to the proper eigenvector partition.

1.10.1.4 Dynamic Analysis

Manual substructuring may be used with any of the other dynamics rigid formats. The NASTRAN Data Decks will be similar to those used for Normal Modes Analysis. All dynamic loads must be applied in Phase 2. If the SUPØRT card is needed to define free body motions for the structure as a whole, it must be included in Phase 2.

In dynamic analysis, the a-set will include, in addition to all points on the boundary of the substructure, a number of points within each substructure sufficient to define the dynamic response. Since all active degrees of freedom along interior boundaries must be included in u_a, the a-set will contain more degrees of freedom than are needed in dynamic analysis, with a large resulting inefficiency for a very small gain in accuracy. This is a serious consideration because, due to the high density of K_{aa}, the time to perform most of the significant matrix operations in Phase 2 increases nearly as the cube of the number of degrees of freedom in u_a. The situation can be greatly improved by a second stiffness reduction in Phase 2, in which u_a is partitioned into a set, u_c, that will be retained in dynamic analysis, and a set, u_b, that will be eliminated. The u_b set includes the excess degrees of freedom on the interior boundaries. The second stiffness reduction in Phase 2 is defined by listing the members of the u_b set that will be eliminated on ØMIT cards. These omitted degrees of freedom must reference the scalar points associated with the pseudostructure.

In Phase 3 for dynamics, each NASTRAN substructure is restarted with the partition of the Phase 2 solution vector, or eigenvector, for each substructure. All normal data reduction

procedures may then be applied. In dynamic analysis, Phase 3 can be omitted if output requests are restricted to the response quantities for the scalar points of the pseudostructure. In this case, the output and partition modules can be omitted from the Phase 2 runs, as their only purpose is to serve as input for the Phase 3 runs. If output is desired for dependent response quantities or element stresses and forces, a Phase 3 run must be made for each substructure of interest.

1.10.1.5 DMAP Loops for Phase 2

The DMAP sequences for the substructure example in Section 1.10.1.1 uses repeated blocks of code for each substructure. Cards 209 through 215 are associated with input for substructure 1. Cards 216 through 222 perform the same operations for substructure 2. Likewise, cards 230 and 231 are associated with output for substructure 1, and cards 232 and 233 are associated with output for substructure 2. If a large number of substructures are used, it is more convenient to use a DMAP loop, rather than repeating blocks of code. DMAP loops are constructed by placing a LABEL statement at the beginning of the loop and an REPT statement at the end of the loop. The number of times the REPT statement must be executed is set by an integer constant.

The series of statements represented by cards 209 through 222 (in Table 5) can be replaced with the following sequence of DMAP operations:

```
PARAM     // C,N,NØP / V,N,INP=1 $
LABEL     BLØCK1 $
INPUTT1   / E,KGGA,PGA,, / C,N,-3 / V,N,INP $
MERGE,    ,,,KGGA,E, / KGGTA $
ADD       KGG,KGGTA / KTA $
EQUIV     KTA,KGG / TRUE $
MERGE,    ,PGA,,,,E / PGTA / C,N,1 $
ADD       PGT,PGTA / PTA $
EQUIV     PTA,PGT / TRUE $
PARAM     // C,N,ADD / V,N,INP / V,N,INP / C,N,1 $
REPT      BLØCK1,1 $
```

The LABEL, BLØCK1, is shown at the beginning of the loop, and the REPT statement is shown at the end. The integer in the REPT statement is set to one less than the number of substructures,

which in this case is one. The PARAM statement preceding the REPT statement is used to increment the second parameter of INPUTT1 by one each time through the loop. This causes the information to be read from a different tape each time through the loop. This DMAP loop does not check the label before reading the information on the input tape. The fact that the same names are used for the matrices each time through the loop does not cause any difficulty, as the matrices are located by their position on the tape, rather than by name.

If a DMAP loop is used for the input sequence, consideration must be given to its effect on the output sequence. Since the partitioning vectors were not saved on each pass through the DMAP loop for the input sequence, it is necessary to recover this information for use in the output sequence. This might be done by rerunning INPUTT1 to reread the partitioning vectors as needed, or perhaps by inserting the DMI cards for the partitioning vectors in the Bulk Data Deck for Phase 2. If Phase 3 runs are not required, no output sequence is necessary.

1.10.1.6 Identical Substructures

In the case of identical substructures, the substructuring procedures can be organized to take full advantage of the repetitive parts. The substructures only have to appear identical in Phase 1. The loading conditions and boundary conditions used in Phase 2 may be quite different for the otherwise identical substructures. The Phase 1 substructures must have identical geometry, including the global coordinate systems used on the boundary grid points.

Only a single Phase 1 run is made for each group of identical substructures. Since the identical substructures will be coupled in different ways during Phase 2, a different partitioning vector must be generated for each use of the identical substructures in Phase 2. These multiple partitioning vectors can be placed on the same output tape from Phase 1, which also contains the single set of structural and loading matrices for the group of identical substructures.

The user may choose to make one or more Phase 3 runs for the members of a group of identical substructures. If the loading conditions and boundary conditions are also identical for the group of identical substructures, a single Phase 3 run will give all information of interest. However, if the boundary conditions and/or loading conditions are different for the various members of the group of identical substructures, it will probably be desirable to make a separate Phase 3 run for each of the substructures used in the complete structural model.

SUBSTRUCTURING

The use of identical substructures not only saves time in computer runs for Phase 1 and perhaps for Phase 3, but also substantially reduces the effort associated with the preparation of the structural model in the Bulk Data Deck. In some sense, substructuring procedures with identical substructures can be thought of as being a form of data generation. Although substructuring is usually used because of problem size, it may be desirable, in some cases, to use substructuring because of the repetitive nature of the structure, and a consequent saving in data generation effort.

Table 1. Data Deck for Phase 1 of Substructure 1.

```
NASTRAN   FILES = (INPT,NPTP)
ID        PHASE,ØNE $ SUBSTRUCTURE 1
TIME      2
CHKPNT    YES
APP       DISP
SØL       1,9
ALTER     100
JUMP      LBL7 $
ALTER     118
FBS       LØØ,UØØ,PØ/UØØV $
CHKPNT    UØØV $
ØUTPUT1   E1,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP1 $
ALTER     119,164
ENDALTER
CEND
TITLE = PHASE ØNE - SUBSTRUCTURE 1
SPC = 101
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10
ASET	3	126							
CBAR	1	10	1	2		1.0		1	
CBAR	2	10	2	3		1.0		1	
DMI	E1	0	2	1	1		3	1	
DMI	E1	1	1	1.0	1.0	1.0			
GRID	1						345		
GRID	2		240.				345		
GRID	3		480.				345		
MAT1	11	30.+6							
PBAR	10	11	60.	500.					
SPC	101	1	12						
ENDDATA									

Table 2. Comments for Phase 1, Substructure 1 Data Deck.

Card No.	Refer to Table 1 for input cards described below.
103	This run will be checkpointed, so that a restart can be made for Phase 3. The user must allocate space for the checkpoint file, NPTP. (The NPTP file is presumed to be copied to tape at the end of the job.)
105	Rigid format 1 (Series Ø), Static Analysis, will be used for this problem without property optimization.
106	Insert the following statement after DMAP statement No. 100.
107	Jump around the Rigid Body Matrix Generator modules. The solution for $\{u_a\}$ will be performed in Phase 2.
108	Insert the following three statements after DMAP statement No. 118.
109	Use the module FBS to solve for $\{u_o^o\}$ the displacement of the o-set relative to the a-set points.
110	Write displacement vector UØØV on the New Problem Tape.
111	Use the module ØUTPUT1 to write the DMI matrix given on cards 121 and 122, along with the stiffness matrix KLL, and the load vector PL on User Tape 1 (USERTP1). The user must allocate space for the User Tape file, INPT. (The INPT file is presumed to be copied to tape at the end of the job.) The details of the call for DMAP module ØUTPUT1 and other DMAP information are given in Section 5.
112	Delete the data recovery modules.
116	Select single-point constraint set 101.
118	Defines grid point 3 as a boundary point between substructures.
119, 120	Connection cards defining bar elements in substructure 1.
121, 122	Direct Matrix Input cards that define the partitioning vector for use in Phase 2. The entries on these cards are discussed below.
123, 124, 125	These cards define the grid points in substructure 1.

Table 2. Comments for Phase 1, Substructure 1 Data Deck (continued).

Card No.	Refer to Table 1 for input cards described below.
126	Defines the material for the elements in substructure 1.
127	Defines the properties of the elements in substructure 1.
128	Defines single-point constraint set 101. Components 1 and 2 are constrained at grid point 1 in substructure 1.

Table 3. Data Deck for Phase 1, Substructure 2.

```
150a NASTRAN   FILES = (INPT,NPTP)
150b ID        PHASE,ØNE $ SUBSTRUCTURE 2
151  TIME      2
152  CHKPNT    YES
153  APP       DIAP
154  SØL       1,9
155  ALTER     100
156  JUMP      LBL7 $
157  ALTER     118
158  FBS       LØØ,UØØ,PØ/UØØV $
159  CHKPNT    UØØV $
160  ØUTPUT1   E2,KLL,PL,,//C,N,-1/C,N,0/C,N,USERTP2 $
161  ALTER     119,164
162  ENDALTER
163  CEND
164  TITLE = PHASE ØNE - SUBSTRUCTURE 2
165  SPC = 201
166  LØAD = 202
167  BEGIN BULK
```

	1	2	3	4	5	6	7	8	9	10
168	ASET	3	126							
169	CBAR	3	10	3	4		1.0		1	
170	CBAR	4	10	4	5		1.0		1	
171	CBAR	5	10	5	6		1.0		1	
172	DMI	E2	0	2	1	1		3	1	
173	DMI	E2	1	1	1.0	1.0	1.0			
174	FØRCE	202	3		1000.		-1.0			
175	FØRCE	202	4		1000.		-1.0			
176	GRID	3		480.				345		
177	GRID	4		720.				345		

Table 3. Data Deck for Phase 1, Substructure 2 (continued).

	1	2	3	4	5	6	7	8	9	10
178	GRID	5		960.				345		
179	GRID	6		1200.				345		
180	MAT1	11	30.+6							
181	PBAR	10	11	60.	500.					
182	SPC	201	6	2						
183	ENDDATA									

Table 4. Comments for Phase 1, Substructure 2 Data Deck.

Card No.	Refer to Table 3 for input cards described below.
160	The partitioning vector for substructure 2 is written on User Tape 2 and is named E2. The user must allocate space for User Tape file, INPT. (The INPT file is presumed to be copied to tape at the end of the job.) It is possible to change the ØUTPUT1 statement and write the results for substructure 2 on the same tape as for substructure 1, if desired.
165	Selects single-point constraint set 201.
166	Selects load set 202.
172, 173	Other than the name E2, the partitioning vector is identical to that for substructure 1.
174, 175	Defines the external loads in load set 202. The load applied to grid point 3 has arbitrarily been placed in substructure 2.
182	Defines single-point constraint set 201 at grid point 6, component 2.

Table 5. Data Deck for Phase 2

```
NASTRAN   FILES = (INPT,INP1,INP2)
ID        PHASE,TWØ
TIME      2
APP       DISP
SØL       1,9
ALTER     1
PARAM     //C,N,NØP/V,N,TRUE=-1 $
ALTER     7,22
ALTER     25,64
INPUTT1   /E01,KGG01,PG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
MERGE,    ,,,KGG01,E01,/KGGT01 $
ADD       KGG,KGGT01/KT01 $
EQUIV     KT01,KGG/TRUE $
MERGE,    ,PG01,,,,E01/PGT01/C,N,1 $
ADD       PGT,PGT01/PT01 $
EQUIV     PT01,PGT/TRUE $
INPUTT1   /E02,KGG02,PG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,    ,,,KGG02,E02,/KGGT02 $
ADD       KGG,KGGT02/KT02 $
EQUIV     KT02,KGG/TRUE $
MERGE,    ,PG02,,,,E02/PGT02/C,N,1 $
ADD       PGT,PGT02/PT02 $
EQUIV     PT02,PGT/TRUE $
ALTER     73,78
ALTER     111,111
SSG1      SLT,BGPDT,CSTM,SIL,,MPT,,EDT,,CASECC,DIT/PG/V,N,LUSET/V,N,NSKIP $
ADD       PGT,PG/PGX $
EQUIV     PGX,PG/TRUE $
ALTER     137,141
ØUTPUT1,  ,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
```

Table 5. Data Deck for Phase 2 (continued).

```
230 PARTN     UGV,,E01/,ULV01,,/C,N,1 $
231 ØUTPUT1   ULV01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
232 PARTN     UGV,,E02/,ULV02,,/C,N,1 $
233 ØUTPUT1   ULV02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
234 SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,PGG,QG,UGV,,/
              ØPG1,ØQG1,ØUGV1,,,/C,N,STATICS $
235 ØFP       ØUGV1,ØPG1,ØQG1,,,//V,N,CARDNØ $
236 ALTER     154,156
237 ALTER     158,164
238 ALTER     168,169
    ALTER     172,173
239 ENDALTER
240 CEND
241 TITLE = PHASE TWØ
242 BEGIN BULK
```

	1	2	3	4	5	6	7	8	9	10
243	DMI	KGG	0	6	1	2		3	3	
244	DMI	KGG	1	1	0.0					
245	DMI	PGT	0	2	1	2		3	1	
246	DMI	PGT	1	1	0.0					
247	SPØINT	1	THRU	3						
248	ENDDATA									

Table 6. Comments for Phase 2 Data Deck.

Card No.	Refer to Table 5 for input cards described below.
204	Rigid Format 1 (Series Ø), Static Analysis, will be used for this problem.
205	Insert the following statement after DMAP statement No. 1.
206	Define the parameter TRUE = -1.
207	Delete the DMAP statements associated with the preparation of the Element Connection Table and structure plots.
208	Delete the DMAP statements associated with matrix assembly.
209	Insert the DMAP module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 1. These matrices have been renamed E01, KGG01, and PG01, respectively. The user must arrange to have the tape mounted that was prepared at the end of Phase 1 run on substructure 1 copied to a file designated as INP1.
210	Insert the module MERGE to change the a-set size of the stiffness matrix from Phase 1 to g-size for Phase 2, and designate the output as KGGT01. In this particular case, no change will take place, since the a-size from Phase 1 is the same as the g-size in Phase 2.
211	Insert the module ADD to add the null matrix KGG, defined in the Bulk Data Deck, to KGGT01, and designate the output as KT01.
212	Insert the module EQUIV to equivalence KT01 to KGG.
213	Insert the module MERGE to change the a-size of the load vector from Phase 1 to g-size for Phase 2, and designate the output as PGT01. In this case, no change in size will take place.
214	Insert the module ADD to add the null matrix PGT, defined in the Bulk Data Deck, to PGT01, and designate the output as PT01.
215	Insert the module EQUIV to equivalence PT01 to PGT.
216	Insert the module INPUTT1 to read the partitioning vector, the stiffness matrix, and the load vector from User Tape 2. These matrices which were generated for substructure 2 in Phase 1 are redesigned as E02, KGG02, and PG02, respectively. The user must arrange to have the tape mounted that was prepared at the end of the Phase 1 run for substructure 2 copied to a file designated as INP2.

Table 6. Comments for Phase 2 Data Deck (continued).

Card No.	Refer to Table 5 for input cards described below.
217	Insert the module MERGE to change the stiffness matrix for substructure 2 from a-size in Phase 1 to g-size in Phase 2 and designate the output as KGGT02.
218	Insert the module ADD to add the stiffness matrix for substructure 2 to the stiffness matrix for substructure 1, and designate the output as KT02.
219	Insert module EQUIV to equivalence KT02 to KGG. The matrix KGG now represents the stiffness matrix for the pseudostructure, and will be used for input to Phase 2.
220	Insert the module MERGE to change the load vector from a-size in Phase 1 to g-size in Phase 2.
221	Insert the module ADD to add the loads applied to substructure 2 to the load vector for substructure 1, and designate the output as PT02.
222	Insert the module EQUIV to equivalence PT02 to PGT.
223	Delete the DMAP statements associated with the Grid Point Singularity Processor.
224	Delete the module SSG1 as given in Rigid Format 1.
225	Insert the module SSG1 with the calling sequence modified to remove parts not associated with directly applied loads. Since, for this particular problem, all loads were applied in Phase 1, there will be no output from SSG1.
226	Insert the module ADD to combine the load vector from Phase 2 with the load vectors generated in Phase 1, and designate the output as PGX.
227	Insert the module EQUIV to equivalence PGX to PG. The data block PG now includes all loads from both Phase 1 and Phase 2, and will be used as input to Phase 3.
228	Remove SDR2 and ØFP as given in Rigid Format 1.
229	Insert the module ØUTPUT1 to rewind User Tape 3 and place the label USERTP3 on this file. The user must arrange a third file allocated which is designated as INPT. (It is presumed the INPT file will be copied to a tape at the end of the job.)
230	Insert the module PARTN to separate that part of the solution vector UGV associated with substructure 1, and designate the output as ULV01.

Table 6. Comments for Phase 2 Data Deck (continued).

Card No.	Refer to Table 5 for input cards described below.
231	Insert the module ØUTPUT1 to write the partition of the solution vector associated with substructure 1 on User Tape 3.
232	Insert the module PARTN to separate that part of the solution vector associated with substructure 2, and designate the output as ULV02.
233	Insert the module ØUTPUT1 to write that part of the solution vector associated with substructure 2 on User Tape 3. This will place the solution vectors for both substructures on User Tape 3. (A second tape could be used for the solution vector for substructure 2 by changing the DMAP statement for ØUTPUT1.)
234	Insert the module SDR2 with the calling sequence modified to remove those parts associated with element output.
235	Insert the module ØFP with the calling sequence modified to remove those parts associated with element output.
236	Remove ØFP as given in Rigid Format 1.
237	Remove the DMAP statements associated with the preparation of the deformed structure plots.
238	Remove the statements associated with ERRØR2 and ERRØR4.
243 244	DMI cards used to define the null matrix KGG.
245 246	DMI cards used to define the null matrix PGT.
247	Definition of the three scalar points for the pseudostructure.

Table 7. Data Deck for Phase 3, Substructure 1.

```
NASTRAN   FILES = (INPT,ØPTP)
ID        PHASE,THREE $ SUBSTRUCTURE 1
TIME      2
APP       DIAP
SØL       1,9
ALTER     23,125
INPUTT1   /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
INPUTT1   /ULV,,,,/C,N,0 $
ALTER     128,133
ALTER     165,176
ENDALTER
   (Include Restart Dictionary from Phase 1)
CEND
TITLE = PHASE THREE - SUBSTRUCTURE 1
DISP = ALL
ELFØRCE = ALL
ØLØAD = ALL
SPCFØRCE = ALL
BEGIN BULK
   (No Bulk Data)
ENDDATA
```

Table 8. Comments for Phase 3, Substructure 1 Data Deck.

Card No.	Refer to Table 7 for input cards described below.
304	Rigid Format 1 (Series Ø), Static Analysis, will be used for this problem.
305	Delete all parts of the rigid format, except the data recovery modules.
306	Insert module INPUTT1 to rewind and check the label on User Tape 3. The user must arrange to have the tape mounted that was prepared at the end of the Phase 2 run copied to a file designated as INPT.
307	Insert module INPUTT1 to read the solution vector for substructure 1 from User Tape 3. The solution vector is designated as ULV for input to module SDR1.
308, 309	Remove additional DMAP statements not associated with data recovery operations.
311	Insert the Restart Dictionary punched during the Phase 1 run of substructure 1. The user must arrange to have the checkpoint tape from the Phase 1 run for substructure 1 copied to a file ØPTP for the restart.
314	Request printed output for all displacements of substructure 1.
315	Request printed output of forces for all elements in substructure 1.
316	Request printed output of the load vector for substructure 1. In this particular case, no output will result because no loads were applied to substructure 1.
317	Request printed output for all nonzero single-point forces of constraint on substructure 1.
318	Beginning of Bulk Data Deck.
319	No bulk data cards should be included in the Phase 3 run. However, the BEGIN BULK and ENDDATA cards must be present.
320	End of NASTRAN Data Deck.

Table 9. Data Deck for Phase 3, Substructure 2

```
350a NASTRAN   FILES = (INPT,ØPTP)
350b ID        PHASE,THREE $ SUBSTRUCTURE 2
351  TIME      2
352  APP       DISP
353  SØL       1,9
354  ALTER     23,125
355  INPUTT1   /,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
356  INPUTT1   /ULV,,,,/C,N,1 $
357  ALTER     128,133
358  ALTER     165,176
359  ENDALTER
360     (Include Restart Dictionary from Phase 1)
361  CEND
362  TITLE = PHASE THREE - SUBSTRUCTURE 2
363  DISP = ALL
364  ELFØRCE = ALL
365  ØLØAD = ALL
366  SPCFØRCE = ALL
367  BEGIN BULK
368     (No Bulk Data)
369  ENDDATA
```

Table 10. Comments for Phase 3, Substructure 2 Data Deck.

Card No.	Refer to Table 9 for input cards described below.
355	Insert module INPUTT1 to rewind User Tape 3. The user must arrange to have the tape mounted that was prepared at the end of the Phase 2 run copied to a file, INPT, if it is not already available as a result of the previous run on substructure 1.
356	Insert module INPUTT1 to skip over the solution vector for substructure 1 on User Tape 3, and read the solution vector for substructure 2.
365	The request for printed output of the load vectors will show nonzero loads applied to grid points 3 and 4.

Table 11. Instructions for Modified Phase 2 Data Deck.

1. Remove card 116, SPC set selection for Phase 1 substructure 1 and request SPC set 201 after card 241.
2. Replace card 118 as shown in Table 12 to redefine the a-set for substructure 1.
3. Replace cards 121 and 122 with cards 121, 122, and 122a shown in Table 12 to redefine the partitioning vectors for substructure 1.
4. Card 128 is not required, SPC set definition for substructure 1 (see item 1 above).
5. Remove cards 165 and 166, SPC and load set selection for Phase 1, substructure 2 (see also item 1 above). Select LØAD set 202 and place after card 241.
6. Replace card 168 as shown in Table 12 to redefine the a-set for substructure 2.
7. Replace cards 172 and 173 with cards 172, 173, and 173a shown in Table 12 to redefine the partitioning vectors for substructure 2.
8. Cards 174, 175, and 182 are not required, load definition and SPC definition for substructure 2 (see item 1 above).
9. Replace cards 243 and 245 as shown in Table 12 to conform to new size for pseudostructure.
10. Insert the cards 246a and 246b as shown in Table 12 in the Bulk Data Deck for Phase 2 for definition of the loading condition and boundary condition.
11. Replace card 247 as shown in Table 12 to modify the definition of the pseudostructure to contain 12 scalar points.

Table 12. New Data for Modified Phase 2

	1	2	3	4	5	6	7	8	9	10
118	ASET1	126	1	3						
121	DMI	E1	0	2	1	1		12	1	
122	DMI	E1	1	1	1.0	1.0	1.0	1.0	1.0	+E11
122a	+E11	E1	1.0							
168	ASET1	126	3	4	5					
172	DMI	E2	0	2	1	1		12	1	
173	DMI	E2	1	4	1.0	1.0	1.0	1.0	1.0	+E21
173a	+E21	E2	1.0	1.0	1.0	1.0				
243	DMI	KGG	0	6	1	2		12	12	
245	DMI	PGT	0	2	1	2		12	1	
246a	SLØAD	202	5	1000.	8	1000.				
246b	SPC1	201		1	2	11				
247	SPØINT	1	THRU	12						

Table 13. Phase 1 Normal Modes Analysis Data Deck.

```
NASTRAN   FILES = (INPT,NPTP)
ID        PHASE,ØNE $ NØRMAL MØDES
TIME      2
CHKPNT    YES
APP       DISP
SØL       3,0
ALTER     86,126
ØUTPUT1   E10,KAA,MAA,,//C,N,-1/C,N,0/C,N,USERTP1 $
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

Table 14. Phase 2 Normal Modes Analysis Data Deck.

```
NASTRAN   FILES = (INPT,INP1,INP2)
ID        PHASE,TWØ $ NØRMAL MØDES
TIME      2
APP       DISP
SØL       3,0
ALTER     1
PARAM     //C,N,NØP/V,N,TRUE=-1 $
ALTER     6,49
INPUTT1   /E01,KGG01,MGG01,,/C,N,-1/C,N,1/C,N,USERTP1 $
MERGE,    ,,,KGG01,E01,/KGGT01 $
ADD       KGG,KGGT01/KT01 $
EQUIV     KT01,KGG/TRUE $
MERGE,    ,,,MGG01,E01,/MGGT01 $
ADD       MGG,MGGT01/MT01 $
EQUIV     MT01,MGG/TRUE $
INPUTT1   /E02,KGG02,MGG02,,/C,N,-1/C,N,2/C,N,USERTP2 $
MERGE,    ,,,KGG02,E02,/KGGT02 $
ADD       KGG,KGGT02/KT02 $
EQUIV     KT02,KGG/TRUE $
MERGE,    ,,,MGG02,E02,/MGGT02 $
ADD       MGG,MGGT02/MT02 $
EQUIV     MT02,MGG/TRUE $
ALTER     57,62
ALTER     119,120
ØUTPUT1   LAMA,,,,//C,N,-1/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E01/,PHIA01,,/C,N,1 $
ØUTPUT1   PHIA01,,,,//C,N,0/C,N,0/C,N,USERTP3 $
PARTN     PHIG,,E02/,PHIA02,,/C,N,1 $
ØUTPUT1   PHIA02,,,,//C,N,0/C,N,0/C,N,USERTP3 $
```

Table 14. Phase 2 Normal Modes Analysis Data Deck (continued).

```
SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,QG,PHIG,,/
          ,ØQG1,ØPHIG,,,/C,N,REIG $
ØFP       ØPHIG,ØQG1,,,,//V,N,CARDNØ $
ALTER     122,126
ALTER     128,129
ENDALTER
CEND
   (Case Control Deck)
BEGIN BULK
   (Bulk Data Deck)
ENDDATA
```

Table 15. Phase 3 Normal Modes Analysis Data Deck.

```
NASTRAN   FILES = (INPT,ØPTP)
ID        PHASE,THREE $ NØRMAL MØDES
TIME      2
APP       DISP
SØL       3,0
ALTER     22,107
INPUTT1   /LAMA,,,,/C,N,-1/C,N,0/C,N,USERTP3 $
INPUTT1   /PHIA,,,,/C,N,0 $
ALTER     127,134
ENDALTER
   (Include Restart Dictionary from Phase 1)
CEND
   (Case Control Deck)
BEGIN BULK
   (No Bulk Data)
ENDDATA
```

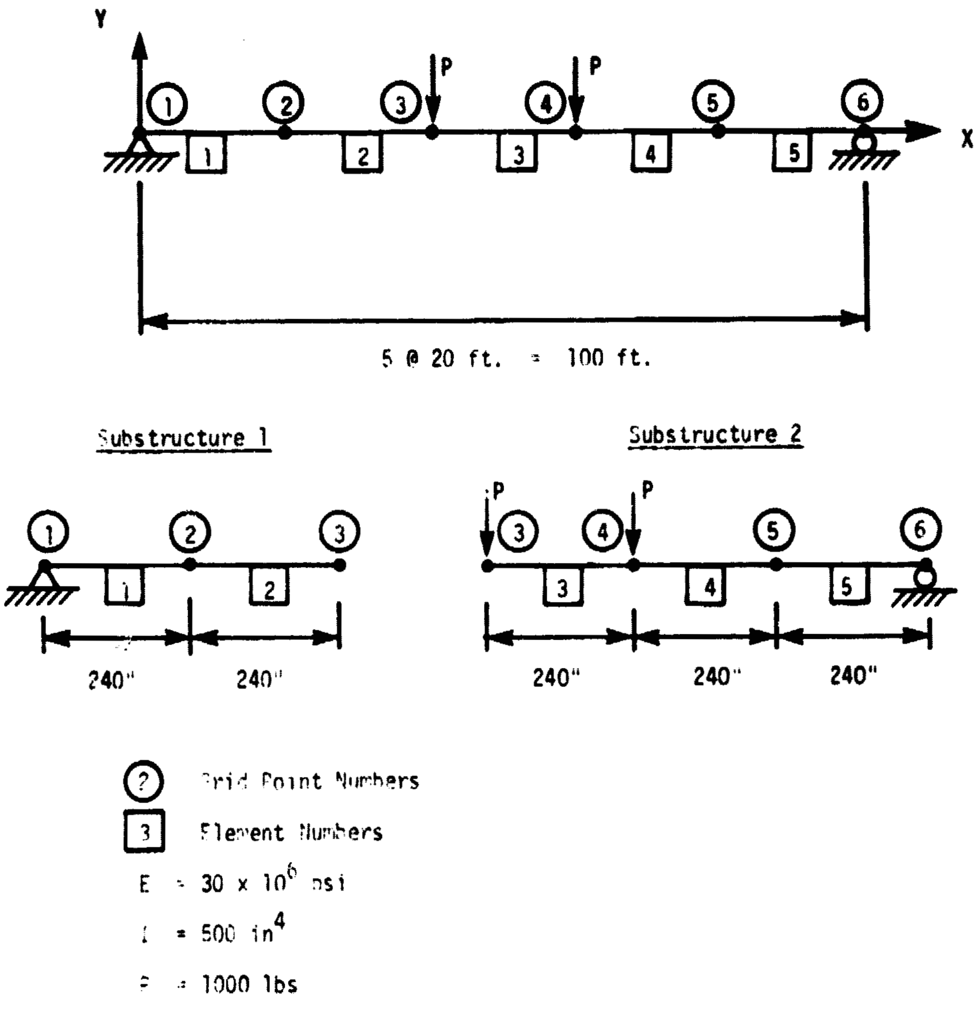


Figure 1. Manual substructuring problem.

1.10.2 Automated Multi-Stage Substructuring

Large and complex structural analysis problems can be solved for static response and/or normal mode shapes using the automated multi-stage substructuring features of NASTRAN. As with all substructuring approaches, the user subdivides the intended model into a set of smaller, more elementary partitions called basic substructures. These components of the whole structure can be modeled independently, checked for accuracy, and then assembled automatically all at once or in stages to form a composite model representing the whole structure for final solution.

In order to effectively employ this automated substructuring capability of NASTRAN for static and normal modes analyses, the user should gain an overall understanding of the basic program design concepts, the data base on which it operates, and the control functions provided. These topics are discussed in the sections which follow. Suggestions, recommendations, and cautions to be observed when using automated substructuring are presented in Section 1.10.2.6. A complete example of a substructuring analysis with listings and explanations of input data cards is included in Section 1.10.2.7. The new user would benefit greatly by executing this example as his first test of the automated substructuring system.

A detailed description of the substructuring control cards and a summary of pertinent bulk data cards is provided in Section 2.7 of this manual. A detailed description of each of these bulk data cards is included alphabetically along with all other bulk data cards in Section 2.4. The basic design concepts used in developing this automated substructuring capability are described below. The theory is presented in Section 4.6 of the Theoretical Manual.

1.10.2.1 Basic Concepts

Automated substructuring analysis is available for use with NASTRAN Rigid Formats 1, 2, and 3. This provides capability for static analysis, static analysis with inertial relief for unsupported structures, and normal modes analysis. The capability allows an unlimited number of substructures to be combined and/or reduced in any sequence desired. Each substructure is represented by its mass and stiffness matrices. A reduction in size or condensation of these matrices is accomplished using the Guyan reduction technique.

Although the NASTRAN substructuring system may be used for small and moderate size problems, several features are available to accommodate very large problems. The most important of these features is the automated data base management system used to maintain the Substructure Operating

File (SØF) on which all pertinent matrix and substructural loading data and associated control files are stored. This SØF carries all the information needed from run to run throughout a substructuring analysis.

Processing automated substructuring analyses is subdivided into three phases similar to those described earlier for manual substructuring. The usual analysis proceeds as follows. First, several separate Phase 1 executions are performed, one for each basic substructure. Second, one or more Phase 2 executions may be performed. In a Phase 2 run, any number of substructure reductions and/or combinations, resulting in higher level (meaning more complex) pseudostructures, may be performed. Phase 2 processing may be halted at any stage of model assembly and restarted in a subsequent Phase 2 execution. The results at each step in the operation are stored on the SØF so as to be available for subsequent execution. The final steps of a Phase 2 operation would be the solution step for the highest level structure and the data recovery steps with limited output capability (displacements, forces of constraint, and applied loads only) for any lower level substructure. Complete and detailed data recovery for the basic substructures must be obtained by separate Phase 3 executions, one for each basic substructure. This level of data recovery may include any or all of the NASTRAN output normal for a non-substructure analysis.

Automated substructuring allows each basic substructure to be defined independently. This concept is represented by three key features of the system.

1. There are no restrictions as to duplication of grid point or element identification numbers, load sets, individual coordinate systems, etc. All data for a given substructure is associated with an assigned unique name for that structure. The only data restriction is one of proper modeling, i.e., common boundaries require grid points to be located at the same point in space for each connecting substructure.

2. No substructure may appear as a component of another substructure more than once; and no degrees of freedom within a substructure may be connected ("combined") to other degrees of freedom in that same substructure except by multipoint constraints imposed at the solution step operation.

3. All pertinent substructure data are stored on the SØF, an expandable direct access file. This file may be selectively edited and/or dumped to tape and transmitted to another user who may have need for the data. Provision is made for automated tape conversion among

CDC, IBM, and UNIVAC computers to facilitate such data transmittal between different users. Use of this file is described in Section 1.10.2.4.

Control of the automated substructuring system is obtained through the use of linguistic commands, similar to those of Case Control. These commands are placed in the Substructure Control Deck shown in Figure 2. This Substructure Control Deck is input between the Executive Control and Case Control Decks.

Each substructure control command is automatically translated into appropriate DMAP ALTER cards to augment the requested Rigid Format sequence. The user may also include his own DMAP ALTER commands, or he may modify a previously defined DMAP sequence. A description of how the user may interface with this NASTRAN-generated substructuring DMAP is presented in Section 2.7.2. Listings of the DMAP ALTERs generated by each substructure command are presented in Section 5.9. Descriptions of the corresponding modules provided for substructuring are found in the NASTRAN Programmer's Manual.

1.10.2.2 Substructure Operations and Control Functions

User control of the automated multi-stage substructuring system is obtained via the Substructure Control Deck commands. The key terms used to describe these commands and their functions are defined in Table 16. A summary of the substructuring command options is presented in Table 17. Some of these commands require specific bulk data cards which are listed for easy reference in Table 18. The user should also refer to Section 2.7 for a complete description of the Substructure Control Deck commands and to Section 2.3 for detailed descriptions of the corresponding bulk data cards.

The operation and control functions of automated substructuring analysis are best illustrated and explained using the "tree" structure presented in Figure 3. This figure defines the geneology of all the component substructures used in building a final model. Basic substructures are created at the Phase 1 level. Substructures "A," "B," and "E" are shown in solid boxes indicating they were formed from actual data deck submittals and are physically different models. The dotted boxes are called "image" substructures and are the result of an EQUIVALENCE operation rather than an actual Phase 1 data deck submittal. The EQUIVALENCE operation defines a new substructure which is a duplicate of an existing substructure and automatically creates all equivalent lower level component substructures. Thus, space is saved on the data files by eliminating storage of redundant matrix data. A four-bladed propeller, for example, could be seen to consist of four

identical components and, hence, only one need by explicitly modeled. The other three blades could be defined solely by using the EQUIVALENCE command.

The image substructures exist in name only. Note in Figure 3 that the names of the image structures are identical to the equivalent parent structure, with the exception of a prefix character. The new names would be created automatically by NASTRAN with the use of the PREFIX subcommand to EQUIVALENCE. These new prefixed names would then be used to reference the appropriate component substructure as if it were created independently.

Note, the term "lower level" refers to the less complex of the component substructures which are used to create a higher level, or more complex substructure.

From the user point of view, all substructures shown in Figure 3, with either solid or dotted boxes, are separate and distinct substructures. They may have different applied loads, boundary conditions, and responses. For example, though only A, B, and E represent actual Phase 1 executions, Phase 3 data recovery executions may be made for A, B, E, XA, XB, YA, YB, YXB, and YE, each of which generally would have different results.

The CØMBINE command (see Table 17) with its numerous subcommands, offers flexibility in the assembly of substructures into a higher level substructure. The CØMBINE capability allows component substructures to be translated, rotated, and/or symmetrically transformed via mirror image transformation for proper positioning in space.

For example, the right wing of an aircraft is first modeled and an EQUIVALENT operation is performed to define an identical duplicate wing. Then, in the CØMBINE operation, a SYMTRANSFØRM is applied so that the wing now appears as the actual left wing (a mirror image of the right wing), and a TRANSFØRM is applied to properly position it on the left side of the aircraft. Caution is advised in that the symmetry transformation (SYMTRAN) is always applied to the component in its own basic coordinate system before the usual translation and rotation (TRANS) for final positioning (see Section 4.6 of the Theoretical Manual).

The REDUCE command causes a Guyan reduction to be performed on an existing substructure. The user specifies which degrees of freedom are to be retained using the BDYC and BDYS (or BDYS1) bulk data cards provided. The degrees of freedom retained are all called boundary degrees of freedom although they all need not ever appear on the boundary with another substructure. Obviously, all degrees of freedom eventually needed for boundary connections must be retained, i.e., they must not be reduced out. However, care must be taken to retain in this boundary set

all the appropriate degrees of freedom needed to represent the dominant displacement patterns for accurate calculation of eigenvalues and eigenvectors for normal modes analyses.

As many EQUIVALENCE, CØMBINE, or REDUCE commands as desired may be used in one or more Phase 2 executions. However, only one SØLVE command is allowed in any single Phase 2 execution. As indicated in the definitions of Table 16, the SØLVE command requests a solution for structural response to applied loads (Rigid Formats 1 and 2) or the calculation of normal modes (Rigid Format 3) of the substructure named in the command.

The RECØVER command is used in Phase 2 to recover the solution data for successively lower level substructures. Only the displacements, forces of constraint, and applied loads can be selectively output for any component substructure during these Phase 2 operations. The BRECØVER command is then used in a Phase 3 execution to obtain all the detail response output normally provided by NASTRAN for each desired <u>basic</u> substructure.

Using the PLØT command, only undeformed plots may be requested in a Phase 2 execution. Deformed plots can only be obtained from a Phase 3 execution.

The user controls each step in the analysis by specifying the appropriate commands to be executed and the substructure names, such as A, B, YC, etc. (see Figure 3), of each substructure to be used in that step.

To reduce the potential for input error and to simplify the bookkeeping tasks, all specific references to loadings and grid points for connection, boundary sets, and constraints, etc. are made with respect to the <u>basic</u> substructure name only. For these reasons, no component substructure may be used more than once while building the solution structure. That is, every component named in any substructure must be unique. If the same component substructure is to be used more than once, e.g., identical components are to be used to create the full model, the EQUIVALENCE operation should be used as described earlier to assign unique names to all substructures comprising that component.

Substructure names are allowed no more than eight alphanumeric characters. Notice in the EQUIVALENCE operation shown in Figure 3, the required subcommand PREFIX generates an additional character which is placed ahead of the existing name as a prefix to the parent substructure name. Care must be taken with successive EQUIV operations to monitor the growth of image substructure names so as not to exceed the eight-character limit. If the limit is exceeded, the right-most character will be truncated. Therefore, it is possible to inadvertently create duplicate

C-2

substructure names as more prefixes are added. It is recommended, therefore, that the entire tree structure for the analysis be prepared ahead of time to help avoid these problems. This pre-planning also will be an invaluable aid to the task of data preparation and proper sequencing of the individual steps in the analysis.

1.10.2.3 Input Data Checking and Interpretation of Output

The automated substructuring system provides several methods for input data checking, diagnostic output, and substructure-oriented data output.

A principal facility for input data checking is the RUN=DRY command. This option allows the user to validate the command structure and data without actually performing the more time consuming matrix operations. Assuming the input is found to be consistent, the run may be resubmitted with the RUN=GØ option to complete the matrix processing.

Also available is a RUN=STEP option (the default option) which first checks the data and then executes the matrix operations one step at a time. If errors are detected in the data, the matrix operations are skipped and the remainder of the processing sequence is executed as a DRY run only.

The user also is allowed to process only selected matrix data. If, for example, after having assembled the solution structure, new loading conditions are to be added or normal modes are desired but the mass matrix is not available, the necessary sequence of matrix operations can be requested using the RUN=GØ option to process the new load or mass matrix data only. The ØPTIØNS command, described in Section 2.7, causes selective processing of mass (M), stiffness (K), or load (P) data only. The PA option (load append) is used when new Phase 1 load vectors are to be added to the set of existing load vectors. Note that when using the ØPTIØNS command, if existing substructure data items are to be recreated (see Table 19), the old data must first be removed using the EDIT or DELETE commands as described in the next section. This is necessary because only one item of a given type may be allowed on the SØF for any particular substructure.

All the relevant substructuring data generated by the program may be displayed with the ØUTPUT command described in Section 2.7. Both the CØMBINE and REDUCE operations involve specification of grid point and degree of freedom data related to the basic substructures involved. The automatically generated or manually specified connectivities are critical to the CØMBINE operation. Using these output options, the information can be obtained to explicitly verify all connectivities. The REDUCE operation requires the user to specify the degrees of freedom to be retained. These

also are identified by basic substructure grid point numbers. If desired, these same output options can be used to obtain lists of all the retained degrees of freedom of the resulting pseudostructure to help verify the resulting model. The following paragraphs describe examples of the possible output that can be requested.

The table shown below may be used to verify all substructure connectivities. This, and the other examples of diagnostic output to be described later, are reproductions of actual problem output requested under the CØMBINE command used to create a pseudostructure named WINDMILL from component substructures RING and VANR.

SUMMARY ØF PSEUDØSTRUCTURE CØNNECTIVITIES

INTERNAL PØINT NØ	INTERNAL DØF NØ	DEGREES ØF FREEDØM	RING	VANR
34	67	12	RING 146	
35	69	12	RING 147	
36	71	12	RING 148	
37	73	12	RING 103	VANE 1
38	75	12	RING 106	VANE 2
39	77	12	RING 109	VANE 3
50	79	12		VANE 13
41	81	12		VANE 14

The column heading "INTERNAL PØINT NØ" references the equivalent of internally generated "grid points" for the resulting pseudostructure. "INTERNAL DØF NØ" references the internally sequenced first degree of freedom (row or column number) in the matrices of WINDMILL for the designated internal grid point. "DEGREES ØF FREEDØM" references the component degrees of freedom in the global coordinate system of the assembled structure associated with the internal grid point. In the example above, the following may be observed:

1. Degrees of freedom 1 and 2 from grid point 109 of basic substructure RING and grid point 3 of basic component VANE in substructure VANE are connected and assigned to internal point 39 of pseudostructure WINDMILL.

2. Displacement components 1 and 2 at internal point 39 are the 77th and 78th degrees of freedom for the matrices of WINDMILL.

Note that only basic substructure names appear in association with grid points. In this example, RING and VANR are the substructures referenced by the CØMBINE command. VANR exists as a higher level substructure with VANE as the basic substructure.

Substructure items EQSS and BGSS, which are created by the CØMBINE or REDUCE operations, are helpful in checking the results of these substructure commands. They are stored along with the other items on the SØF (see Table 19) and can be accessed at any time with the SØFPRINT command. The display of these items, however, is normally requested by the ØUTPUT subcommand of either the CØMBINE or REDUCE commands at the time of their execution.

The EQSS item provides data for each basic substructure relating external or basic substructure grid point numbers to pseudostructure internal grid point numbers. In the example shown below, degrees of freedom 1 and 2 of grid point 102 of basic substructure RING have been assigned to internal grid point 2 of pseudostructure WINDMILL.

EQSS ITEM FØR SUBSTRUCTURE WINDMILL CØMPØNENT RING

GRID PØINT ID	INTERNAL PØINT NØ	CØMPØNENT DØF
102	2	12
105	4	12
108	6	12
111	8	12
114	11	12
117	13	12
120	15	12
123	17	12
126	20	12
129	22	12
132	24	12
135	26	12
138	29	12
141	31	12
144	33	12
147	35	12

In addition to the above data for each basic substructure, the EQSS item also contains summary data for the resultant pseudostructure. A sample is shown below.

EQSS ITEM - SCALAR INDEX LIST FOR SUBSTRUCTURE WINDMILL

INTERNAL PØINT ID	INTERNAL SIL ID	CØMPØNENT DØF
2	3	12
5	9	12
8	15	12
11	21	12
14	27	12
17	33	12
20	39	12
23	45	12
26	51	12
29	57	12
32	63	12
35	69	12

In the above table, the relationships of the internal grid point numbers to the internal degree of freedom numbers (referenced as "INTERNAL SIL ID") and to the component degrees of freedom are defined for pseudostructure WINDMILL. The internal degrees of freedom are referenced as a Scalar Index List (SIL) because all substructure problem degrees of freedom are converted to scalar points for purposes of Phase 2 processing. If desired for special purposes, therefore, these internal degrees of freedom may be referenced as scalar points for use with any of the nonsubstructuring Bulk Data cards to be input to the SØLVE step operations in Phase 2.

The EQSS items and the summary of pseudostructure connectivities table are related. For example, by cross referencing each table it can be seen that internal grid point 35 of substructure WINDMILL has degrees of freedom 1 and 2 assigned to it. These degrees of freedom numbers in the SIL list are 69 and 70, respectively, and these degrees of freedom come from grid point 147 of basic substructure RING.

CØMBINE or REDUCE operations also create the BGSS item. A sample is shown below. The BGSS item contains internal grid point locations for the substructure model. In this example, the BGSS item displays all the internal point numbers for the pseudostructure WINDMILL along with its corresponding location coordinates in that pseudostructure's basic system. The "CSTM ID NØ" column indicates the existence (if any) of local coordinate systems associated with those internal points. If the entry is "0", the displacement components will be in that pseudostructure basic

BGSS ITEM FØR SUBSTRUCTURE WINDMILL

INTERNAL PØINT ID	CSTM ID NØ	C Ø Ø R D I N A T E S X1	X2	X3
1	0	-0.500000E+01	0.100000E+02	0.E+00
2	0	-0.500000E+01	0.150000E+02	0.E+00
3	0	0.E+00	0.100000E+02	0.E+00
4	0	0.E+00	0.150000E+02	0.E+00
5	0	0.500000E+01	0.100000E+02	0.E+00
6	0	0.500000E+01	0.150000E+02	0.E+00
7	0	0.750000E+01	0.750000E+01	0.E+00
8	0	0.100000E+02	0.100000E+02	0.E+00
9	0	0.125000E+02	0.125000E+02	0.E+00
10	0	0.100000E+02	0.500000E+01	0.E+00

system. Otherwise, they will be in a local system which may be verified with the optional printout of the coordinate system transformations (a 3x3 matrix of direction cosines) as stored in the "CSTM" item for that pseudostructure.

Another useful output item is the SUBSTRUCTURE ØPERATING FILE TABLE ØF CØNTENTS (TØC), as shown in Figure 4. In this figure, the substructure tree has been added to the TØC output to help visualize the sample problem. This output is obtained with the command: SØFPRINT TØC. The TØC lists by name all substructures that reside on the SØF, lists the current items available for each substructure, and provides a set of pointers which describe the hierarchy of substructure relationships. The SØF pointer scheme is described by defining the individual column headings shown in the TØC:

IS $\begin{cases} = 0 & \text{Substructure is not an image substructure.} \\ = 1 & \text{Substructure is an image substructure created in an EQUIV operation.} \end{cases}$

SS Points to a substructure which is secondary to the current substructure. In the case where many secondary substructures have been EQUIVed to a single primary substructure, the SS entries form a chain starting with the primary substructure and ending with an SS pointer of zero.

PS Points to the substructure which is primary to the current substructure. PS is non-zero for secondary substructures only.

LL Points to a substructure at the next lower (simpler) level to the current substructure.

CS Points to a substructure which has been combined with the current substructure. The CS entries form a circular chain.

HL Points to the substructure at the next higher (complex) level to the current substructure.

All normal NASTRAN output for each basic substructure, primary or image substructure, is available via a Phase 3 execution. Also, certain output may be recovered in Phase 2 for any or all of the substructures in the solution structure's tree. However, this output is limited to displacements, applied loads, and forces of single-point constraint. The output requested in Phase 2 is labeled by both the pseudostructure and its component basic substructure names.

Some discussion of the forces of constraint, which may be requested as output in both Phase 2 and Phase 3, is required. The Phase 3 calculations for forces of constraint are computed in the normal NASTRAN convention (refer to Section 3.7 of the Theoretical Manual). In a Phase 2 execution, however, the forces of constraint include additional terms. Also, there are differences between the forces of constraint calculated for a static analysis versus those calculated for a normal modes analysis. The calculations for each are described next.

For a Phase 2 static analysis, the forces of constraint $\{q_A\}$ for substructure A are computed using back-substitution as

$$\{q_A\} = [K_A]\{U_A\} - \{P_A\} \quad . \tag{1}$$

The stiffness matrix $[K_A]$ and the solution displacement vector $\{U_A\}$ are defined for all degrees of freedom in substructure A, and $\{P_A\}$ is the applied load vector on substructure A. The equation above may be rewritten as

$$\{F_A\} = \{P_A\} + \{q_A\} = [K_A]\{U_A\} \quad , \tag{2}$$

where $\{F_A\}$ is the total set of forces in equilibrium which act on substructure A. The force vector $\{F_A\}$ contains all the terms due to:

1. Applied forces (applied loads)
2. Inertia forces (applied loads)
3. Single-point constraint forces
4. Multipoint constraint forces

5. Forces transferred from other connected substructures
6. Residual forces due to computer round-off

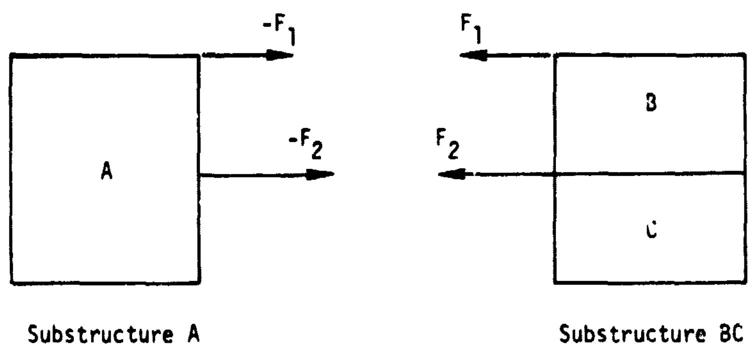
Thus, $\{q_A\}$, the forces of constraint for Phase 2 substructure analysis, contains all terms listed above except the loads applied to substructure A. All points not otherwise constrainted by single- or multipoint constraints or other connecting substructures should be in equilibrium with applied loads. That is, these points should have near zero residual force.

For a Phase 2 normal modes analysis, on the other hand, the equation for forces of constraint becomes

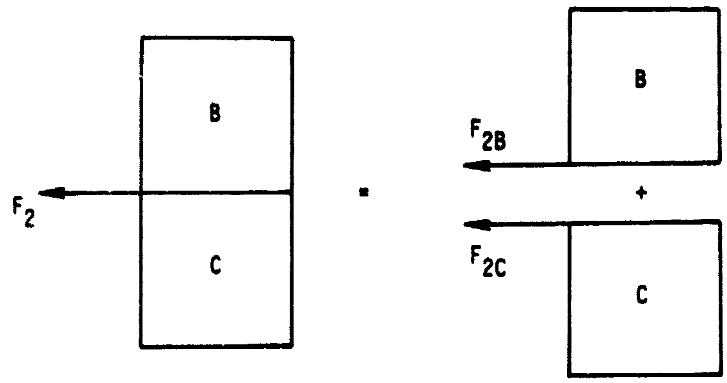
$$\{q_A\}_i = [K_A]\{\phi_A\}_i - \lambda_i[M_A]\{\phi_A\}_i \quad , \tag{3}$$

where $\{\phi_A\}_i$ and λ_i are the i^{th} eigenvector and eigenvalue respectively, and $\{q_A\}_i$ are the forces of constraint for the i^{th} mode. The equation shows that the constraint forces are computed for values of maximum modal deflection ($[K_A]\{\phi_A\}$) and maximum modal acceleration ($-\lambda[M_A]\{\phi_A\}$).

The equations presented above for calculation of forces of constraint provide especially useful information, i.e., the forces of substructure interconnection as shown below.



Forces F_1 and F_2, recovered as forces of constraint for substructure A and for pseudostructure BC, represent the forces of interconnectivity. Force F_2 represents the sum of two component forces, one from each component substructure B and C, acting at their common grid point. The separate contributions to F_2 from each B and C may be determined by using the RECØVER command for the component substructures B and C individually, as shown below.



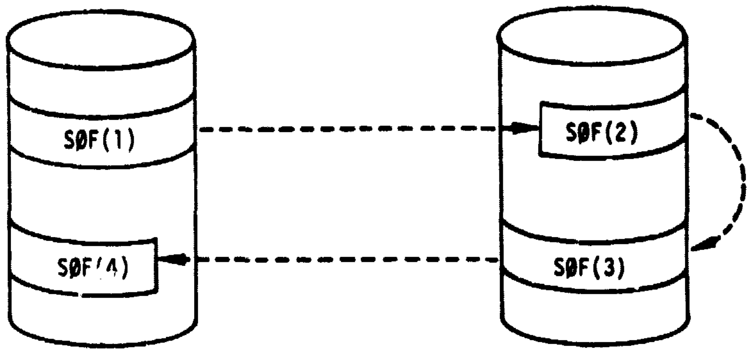
1.10.2.4 Substructure Operating File (SØF)

The data required for each basic substructure and for all subsequent combinations of substructures are stored on the Substructure Operating File (SØF). The SØF data are stored in direct access format on disk or drum during a NASTRAN execution. These data may also be stored on tape between runs for backup storage or for subsequent input to other computers. Schematic diagrams of data flow for each of the three phases of execution are given in Figure 5.

The SØF file, which contains the data items listed in Table 19, is used to communicate all required data between each phase of operation and between each step of the Phase 2 operation. Thus, the user is allowed to develop his analysis in separate steps without requiring the checkpoint/restart feature of NASTRAN. A Phase 1 run is required to build each basic substructure and place its data on the SØF prior to any Phase 2 reduction or combination using that substructure. Using that data, component pseudostructures may be assembled in stages from these basic substructures and added later to other component substructures already on the SØF file. Also, the same SØF may be used to build the data files for more than one solution structure at a time.

Once the final solution model is established, the solution may be obtained and results recovered for any level, component pseudo- or basic substructure. However, detail element stresses and element forces or support reactions specified with the basic substructure can be recovered only in Phase 3. These Phase 3 results may be recovered either by using the original data deck or by restarting from a checkpointed Phase 1 execution.

The SØF is structured as a single logical file used to store all data necessary for a complete multi-stage substructuring analysis. However, the SØF may actually reside on from one to ten physical files. These physical files would be chained together to form the single logical file for use in the analysis of larger problems. The figure below shows the basic arrangement of an SØF on disk or drum.



Each physical file comprising the SØF is a direct access file. These disk or drum files are not used by NASTRAN GINØ operations. NASTRAN treats them as external user files. In a substructure analysis, NASTRAN stores data on the SØF which must be saved from run to run. Therefore, it is the user's responsibility to maintain the physical files comprising the SØF from one execution to the next. For large disk files which may arise in some substructuring problems, it may be advisable to store the SØF on tape for backup protection between executions. The user should refer to the DUMP, RESTØRE, SØFØUT, and SØFIN commands for this capability or use operating system utilities.

The SØF declaration in the Substructure Control Deck is used to define the physical files which make up the SØF. See Section 2.7 for a complete description of the SØF declaration. An SØF composed of only one physical file which already exists would be declared as follows:

SØF(1)=SØF1,200,ØLD (CDC example)

A new SØF composed of three physical files could be declared as follows on the first execution with this particular SØF logical file:

SØF(1)=SØF1,200,NEW

SØF(2)=SØF2,200

SØF(3)=SØF3,400

The parameter "NEW" is never used again on any subsequent execution with this SØF. If it were used, all data on that SØF logical file would be lost. For example, to add a new physical file on a subsequent execution, simply add its declaration, i.e., SØF(4)=SØF4,600. Again, do not declare this as a "NEW" file or the whole logical SØF file will be re-initialized and all existing data will be lost. (Refer to the SØF command in Section 2.7 for machine dependent restrictions.)

All data stored on the SØF is accessed via the substructure name. For each substructure, various types of SØF data may be stored. These types of data are called items and are accessed via their item names. Thus, the substructure name and item name are all that is required to access any block of data on the SØF. The items which can be stored for any substructure are described in Table 19. The program automatically keeps track of the data, stores the data as it is created, and retrieves these data when required. The user's only responsibility is to maintain the file. It must be accessible by the system when needed. The user must remove items generated from data containing input errors and/or if that data is no longer needed for subsequent analyses. Also, data may be selectively stored on a backup tape for later retrieval, thus releasing needed space for subsequent operations.

1.10.2.5 The Case Control Deck for Automated Substructuring Analyses

The Case Control Deck for substructuring analysis controls loading conditions, constraint set selection, output requests, and method of analysis just as in any non-substructuring analysis. However, in a substructuring analysis, there are very important relationships among the Case Control Decks to be input for each of the three Phases of substructuring. Compatibility among the substructuring phases must be maintained for load sets, constraint sets, and subcase definitions.

The following requirements must be satisfied by the Case Control Deck in Phase 1:

1. Constraint set selection (MPC, SPC) must be above the subcase level. That is, only one set of constraints is allowed in Phase 1 for all loading conditions.

2. One subcase must be defined for each loading condition which is to be saved on the SØF. The loading condition may consist of any combination of external static loads, thermal loads, element deformation loads, or enforced displacements. Loading conditions which are not saved on the SØF in Phase 1 cannot be used in any solution in Phase 2.

The Phase 2 Case Control Deck is exactly like the Case Control used in a non-substructuring analysis. Only the TITLE and BEGIN BULK cards are needed except when plots are requested or when there is a SØLVE command in the Substructure Control Deck. In this latter case, the subcase definitions, load and constraint set selections, etc. are used in the usual fashion to control the solution process.

Output requests in Case Control are honored only if there is a PRINT subcommand under the RECØVER command in the Substructure Control Deck. If a RECØVER command with a PRINT subcommand is used, the Case Control should be identical (except for output requests) to that used to obtain the solution being printed.

The following requirements must be satisfied by the Case Control Deck in Phase 3:

1. Constraint sets (MPC, SPC) must be identical to those used in Phase 1 for this substructure.

2. The subcase definition for load set IDs must be identical to those used in Phase 1 for this substructure including those for appended loads, if any. All load definitions must appear in the order generated.

3. The subcase definition for the Phase 3 output requests for solution vectors generated in Phase 2 must be merged with the above subcase definition for load set IDs. Note, the ØLØAD output requested in Phase 3 will correspond to the load factors defined during Phase 2 solution, not those defined by Phase 3 Case Control.

The number of Phase 3 subcases required is the maximum of those defined in either Phase 1 or Phase 2. All output requests will correspond to the Phase 2 subcase sequence, starting with the first subcase defined in Phase 3. It is essential to assign the same thermal and element deformation loadings to the same subcases in both Phase 1 and Phase 2 in order to provide the correct load correction data to the Phase 3 output processing of element forces and stresses.

1.10.2.6 User Aids for Automated Substructuring Analysis

The following suggestions, recommendations, and cautions should be considered when using automated substructuring. The most economical analyses may be performed using relatively small basic substructures or by performing significant reductions in Phase 1 (using ØMIT or ASET bulk data cards). When using Guyan reduction, either reduce most degrees of freedom (many more than half) or very few degrees of freedom (many less than half). Note that the resulting matrices are usually dense and, hence, may take up more space on the SØF than the original matrices.

In the event that additional new loading conditions are required, the LØDAPP (Load Append) feature may be used. This feature, described in Section 2.7, allows the user to avoid performing redundant Phase 2 computations.

It should be remembered that due to the data base protection features, at no time are there any SØF items destroyed by NASTRAN without a specific user command in the Substructure Control Deck. In addition, NASTRAN does not allow more than one substructure item (see Table 19) to exist for each substructure at any one time. As a result, some operations such as a repeated SØLVE might require the user to manually edit out previously generated solution data items or any recovered solution data items before the operation could be repeated. That is, SØLN and UVEC items (the load factor or eigenvalue data file and displacement vectors respectively) created in an earlier SØLVE operation should be deleted if a new solution with new loads or frequency range is desired for the same substructure. These same items must also be edited out from each lower level substructure for which the new solution data will be recovered.

By using the EQUIVALENCE operation to create an identical structure, a new solution may be obtained for the same structure without deleting the older solution data items, as required in the example above.

Substructures which may change due to design iterations should be combined with other structures as late in the sequence of CØMBINE operations as possible. This will minimize the cost of creating a new solution structure. Also, if the design iteration changes are minor and their impact on other substructures in the model can be neglected, then RECØVER operations need be performed only from the lowest level of substructure affected by the changes. Frequently, these design changes can be evaluated using only the Phase 3 recovery calculations. Care must be taken to maintain compatibility with the degree of freedom list defining the solution displacement vector. That is, the boundary grid points and connections should not be changed.

1.10.2.7 Example of Automated Substructure Analysis

A complete example is presented here to illustrate a simple substructuring analysis. Figure 6(a) shows two basic substructures, TABLE and LEGS. Note that these structures have different basic coordinate systems, as shown in the figure. Figure 6(b) shows a combined structure which is assembled from the two basic substructures. All of the data decks used to generate and analyze the composite structure are listed and described in Tables 20-27. These include the data for the Phase 1 generation of the basic substructures, the Phase 2 assembly of the complete structure, its solution and data recovery, and the Phase 3 data recovery. Figure 7 shows the resultant substructure tree for the Phase 2 run.

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Table 16. Definitions of Substructure Terminology.

Basic Substructure	-	A structure formulated from finite elements in Phase 1.
Boundary Set	-	Set of degrees of freedom to be retained in a Phase 2 reduce operation.
Combine Operation	-	Merge two or more structures by connecting related degrees of freedom. The matrix elements for connected degrees of freedom are added to produce the combined structure matrices, and the substructure load vectors are processed and stored for subsequent combination at solution time.
Component Substructure	-	Any basic or pseudostructure comprising a part of an assembled substructure.
Connection Set	-	Set of grid points and their component degrees of freedom to be connected in adjoining structures.
Equivalence Operation	-	The creation of a secondary substructure equivalent to a primary substructure. Also creates image substructures back to the basic substructure level
Image Substructure	-	A substructure equivalent to an existing component substructure. May have different applied loads and/or solution vectors but has identical stiffness and mass matrices. Image substructures are automatically created as a result of an equivalence operation.
Phase (1, 2, or 3)	-	Basic steps required for multi-stage substructure processing with NASTRAN - creation, combination, reduction, solution and recovery, and detail data recovery.
Primary Substructure	-	Any basic substructure or any substructure resulting from a combine or reduce operation.
Pseudostructure	-	A combination of component substructures.
Reduce Operation	-	Structural matrix and load vector reduction process to obtain smaller matrices.
Secondary Substructure	-	A substructure created from an equivalence operation.
SØF	-	Substructure Operating File. Contains all data necessary to define a structure at any stage, including solutions.
Solution Structure	-	The resulting substructure to be used in the solve operation.
Solve Operation	-	To obtain solutions using the present structural matrices and user-defined input data.

Table 17. Summary of Substructure Commands.

Phase and Mode Control	
# SUBSTRUCTURE	- Defines execution phase (1, 2, or 3)
NAME*	- Specifies Phase 1 or Phase 3 substructure name (not used in Phase 2)
SAVEPLØT	- Requests plot data be saved in Phase 1
ØPTIØNS	- Defines matrix options (K, M, P, or PA)
RUN	- Limits mode of execution (DRY, GØ, DRYGØ, STEP)
# ENDSUBS	- Terminates Substructure Control Deck
SØF Controls	
# SØF	- Assigns physical file for storage of the SØF
PASSWØRD*	- Protects and ensures access to correct file
SØFØUT or SØFIN	- Copies SØF data to or from an external file
PØSITIØN	- Specifies initial position of input file
NAMES	- Specifies substructure name used for input
ITEMS	- Specifies data items to be copied in or out
SØFPRINT	- Prints selected items from the SØF
DUMP	- Dumps entire SØF to a backup file
RESTØRE	- Restores entire SØF from a previous DUMP operation
CHECK	- Checks contents of external file created by SØFØUT
DELETE	- Deletes out selected groups of items from the SØF
EDIT	- Edits out selected groups of items from the SØF
DESTRØY	- Destroys all data for a named substructure and all the substructures of which it is a component

Manditory Control Cards

* Required Subcommand

Table 17. Summary of Substructure Commands (continued).

Substructure Operations	
CØMBINE	- Combines sets of substructures
NAME*	- Names the resulting substructure
TØLERANCE*	- Limits distance between automatically connected grids
CØNNECT	- Defines sets for manually connected grids and releases
ØUTPUT	- Specifies optional output results
CØMPØNENT	- Identifies component substructure for special processing
TRANSFØRM	- Defines transformations for named component substructures
SYMTRANSFØRM	- Specifies symmetry transformation
SEARCH	- Limits search for automatic connects
EQUIV	- Creates a new equivalent substructure
PREFIX*	- Prefix to rename equivalenced lower level substructures
REDUCE	- Reduces substructure matrices
NAME*	- Names the resulting substructure
BØUNDARY*	- Defines set of retained degrees of freedom
ØUTPUT	- Specifies optional output requests
SØLVE	- Initiates substructure solution (statics or normal modes)
RECØVER	- Recovers Phase 2 solution data
SAVE	- Stores solution data on SØF
PRINT	- Stores solution and prints data requested
BRECØVER	- Basic substructure data recovery, Phase 3
PLØT	- Initiates substructure undeformed plots

*Required Subcommand

Table 18. Substructure Bulk Data Card Summary.

Card	Description
Bulk Data Used by Substructure Command REDUCE	
BDYC	- Combination of substructure boundary sets of retained degrees of freedom
BDYS	- Boundary set definition
BDYS1	- Alternate boundary set definition
Bulk Data Used by Substructure Command CØMBINE	
CØNCT	- Specifies grid points and degrees of freedom for manually specified connectivities - will be overridden by RELES data
CØNCT1	- Alternate specification of connectivities
RELES	- Specifies grid point degrees of freedom to be disconnected - overrides CØNCT and automatic connectivities
GTRAN	- Redefines the output coordinate system grid point displacement sets
TRANS	- Specifies coordinate systems for substructure and grid point transformations
Bulk Data Used by Substructure Command SØLVE	
LØADC	- Defines loading conditions for static analysis
MPCS	- Specifies multipoint constraints
SPCS	- Specifies single-point constraints
SPCS1	- Alternate specification of single-point constraints
SPCSD	- Specifies enforced displacements for single-point constraints

Table 19. Substructure Item Descriptions.

EQSS	External grid point and internal point equivalence data
BGSS	Basic grid point coordinates
CSTM	Local coordinate system transformation matrices
LØDS	Load set identification numbers
LØAP	Load set identification numbers for appended load vectors
PLTS	Plot sets and other data required for Phase 2 plotting
KMTX	Stiffness matrix
LMTX	Decomposition product of REDUCE operation
MMTX	Mass matrix
PAPP	Appended load vectors
PVEC	Load vectors
PØAP	Appended load vectors on omitted points
PØVE	Load vectors on points omitted during matrix reduction
UPRT	Partitioning vector used in matrix reduction
HØRG	H or G transformation matrix
UVEC	Displacement vectors or eigenvectors
QVEC	Reaction force vectors
SØLN	Load factor data or eigenvalues used in a solution

Table 20. Phase 1 Data Deck for Substructure TABLE.

```
NASTRAN   FILES = NPTP
ID        TABLE,BASIC
APP       DISP,SUBS
SØL       2,0
TIME      1
CHKPNT    YES
CEND
SUBSTRUCTURE PHASE1
PASSWØRD = PRØJECTX
SØF(1) = SØF1,250,NEW   $ CDC
NAME = TABLE
SAVEPLØT = 1
SØFPRINT  TØC
ENDSUBS
TITLE = TABLE, PHASE ØNE
LØAD = 2
ØUTPUT(PLØT)
SET 1 = ALL
PLØT
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10
CQUAD2	3	2	5	6	4	3			
CTRIA2	1	1	1	2	4				
CTRIA2	2	1	3	4	1				
FØRCE	2	3		10.0	-1.0				
FØRCE	2	4		10.0	-1.0				
GRID	1		0.0	0.0	5.				
GRID	2		0.0	7.	5.				
GRID	3		0.0	0.0	0.0				
GRID	4		0.0	7.	0.0				

Table 20. Phase 1 Data Deck for Substructure TABLE (continued).

	1	2	3	4	5	6	7	8	9	10
29	GRID	5		0.0	0.0	-5.				
30	GRID	6		0.0	7.	-5.				
31	GRID	7						123456		
32	MAT1	1	3.+7		.3	4.3				
33	PQUAD2	2	1	.1						
34	PTRIA2	1	1	.1						
35	ENDDATA									

Table 21. Comments for Phase 1, Substructure TABLE Data Deck.

Card No.	Refer to Table 20 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card.
7	First card of Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTX'.
9	This SØF declaration consists of a single physical file with an index of '1'. Indices must begin with '1' and increase sequentially. It has been named 'SØF1' and gives a maximum size of 250,000 words. Because it is a first declaration (NEW), internal pointers will be set to indicate this SØF contains no data. (See alternate format for IBM and UNIVAC systems in Section 2.7.)
10	The basic substructure to be generated will be identified by the name TABLE.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12	Print a table of contents for the SØF. This includes a list of all substructures and their data items.
13	End of Substructure Control Deck.
15	Selects the load to be saved on the SØF for use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads and element deformation loads may be selected.
16-18	Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
19-35	Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Table 22. Phase 1 Data Deck for Substructure LEGS.

```
NASTRAN   FILES = NPTP
ID        LEGS,BASIC
APP       DISP,SUBS
SØL       2,0
TIME      1
CHKPNT    YES
CEND
SUBSTRUCTURE PHASE1
PASSWØRD = PRØJECTY
SØF(1) = SØF4,250   $ CDC
NAME = LEGS
SAVEPLØT = 1
SØFØUT    INP3
PØSITIØN = REWIND
NAME = LEGS
EDIT(32)  LEGS
ENDSUBS
TITLE = LEGS PHASE ØNE
LØAD = 1
ØUTPUT(PLØT)
SET 1 = ALL
PLØT
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10
CBAR	1	1	1	2	5			2	
CBAR	2	1	3	2	5			2	
CBAR	3	1	4	3	5			2	
FØRCE	1	1		2.0	3.0	.0	4.0		
FØRCE	1	4		2.0	3.0	.0	4.0		
GRID	1		0.0	10.	0.0				

Table 22. Phase 1 Data Deck for Substructure LEGS (continued).

	1	2	3	4	5	6	7	8	9	10
29	GRID	2		5.	10.	0.0				
30	GRID	3		5.	0.0	0.0				
31	GRID	4		0.0	0.0	0.0				
32	GRID	5		100.	100.	0.0		123456		
33	MAT1	1	3.+7		.3	4.3				
34	PBAR	1	1	1.0	50.	100.	10.			
35	ENDDATA									

Table 23. Comments for Phase 1, Substructure LEGS Data Deck.

Card No.	Refer to Table 22 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card.
7	First card of the Substructure Control Deck. Phase 1 is selected.
8	Password protection on the SØF is 'PRØJECTY'.
9	The SØF consists of one physical file with an index of one. (Indices must begin with one and increase sequentially.) The name of the file is 'SØF4' and is has a maximum size of 250,000 words. The file was used previously as an SØF (Phase 1 for TABLE).
10	The basic substructure to be generated will be identified by the name LEGS.
11	Plot set 1 will be saved on the SØF for performing plots of the combined structure in Phase 2.
12-14	After substructure LEGS has been generated and saved on the SØF, it is copied out to user tape INP3.
15	All data items for substructure LEGS are removed from the SØF. (The substructure name remains in the SØF directory, however.)
16	End of Substructure Control Deck.
18	Selects the load to be saved on the SØFfor use in Phase 2. Note that multiple loads may be saved by using multiple subcases. In addition to external static loads, thermal loads, and element deformation loads may be selected.
19-21	Plot control cards are required if the SAVEPLØT subcommand is used in the Substructure Control Deck. These cards are used to define the plot sets for Phase 2 plotting. It is not necessary that a plot tape be set up in Phase 1.
22-35	Standard NASTRAN Bulk Data Deck. These cards define the mathematical model of the basic substructure.

Table 24. Phase 2 Data Deck.

```
ID        SUBSTR,PHASE2
SPP       DISP,SUBS
SØL       1,0
TIME      1
DIAG      23
CEND
SUBSTRUCTURE PHASE2
PASSWØRD = PRØJECTX
SØF(1) = SØF1,250   $ CDC
ØPTIØNS = K,M,P
SØFØUT INP4,TAPE
PØSITIØN = REWIND
NAME = TABLE
SØFPRINT  TØC
CØMBINE   LEGS,TABLE
NAME = SIDEA
TØLER = 0.001
ØUTPUT = 1,2,7,11,12,13,14,15,16,17
CØMPØNENT LEGS
TRANS = 10
EQUIV     SIDEA,SIDEB
PREFIX = B
CØMBINE   SIDEA,SIDEB
NAME = BIGTABLE
TØLER = 0.001
ØUTPUT = 1,2,7,11,12,13,14,15,16,17
CØMPØNENT SIDEB
SYMT = Y
REDUCE BIGTABLE
NAME = SMALTABL
```

Table 24. Phase 2 Data Deck (continued).

```
BØUNDARY = 100
ØUTPUT = 1,2,3,4,5,6,7,8
SØFPRINT  TØC
PLØT      SMALTABL
SØLVE     SMALTABL
RECØVER   SMALTABL
PRINT     BIGTABLE
SAVE      BTABLE
SØFPRINT  TØC
ENDSUBS
TITLE = PHASE TWØ SUBSTRUCTURE
DISP = ALL
SPCF = ALL
ØLØAD = ALL
SPC = 10
SUBCASE 1
LØAD = 10
SUBCASE 2
LØAD = 20
ØUTPUT(PLØT) $ SC 4020 PLØT TAPE
SET 1 = ALL
PLØT
BEGIN BULK
```

1	2	3	4	5	6	7	8	9	10
BDYC	100	LEGS	20	BLEGS	20				+A
+A		TABLE	10	BTABLE	10				
BDYS1	10	4	1	3	4	5			
BDYS1	10	123456	2	6					
BDYS1	20	123456	2	3					
LØADC	10	1.0	LEGS	1	1.0	BLEGS	1	1.0	

Table 24. Phase 2 Data Deck (continued).

	1	2	3	4	5	6	7	8	9	10
60	LØADC	20	1.0	TABLE	2	1.0	BTABLE	2	1.0	
61	SPCS1	10	BLEGS	123456	2	3				
62	SPCS1	10	BTABLE	4	1	3	4	5		
63	SPCS1	10	LEGS	123456	2	3				
64	SPCS1	10	TABLE	4	1	3	4	5		
65	TRANS	10		.0	7.0	-5.0	3.0	11.0	-5.0	+B
66	+B	0.0	8.0	-5.0						
67	ENDDATA									

Table 25. Comments for Phase 2 Data Deck.

Card No.	Refer to Table 24 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP card. DIAG 23 requests an echo of the automatic DMAP alters generated.
7	First card of the Substructure Control Deck. Phase 2 is selected.
8,9	These cards specify the same SØF used in Phase 1 for substructure TABLE.
10	The card causes matrix operations to be performed on stiffness, mass, and load matrices. The default for Rigid Format 1 is stiffness and loads only. However, Rigid Format 2 was selected in the Phase 1 decks. This caused all three matrix types to be generated in Phase 1.
11-13	Basic substructure TABLE is copied from the SØF to user tape INP4.
14	Print the SØF table of contents.
15-20	Perform an automatic combination of substructures TABLE and LEGS. The resultant combined pseudostructure will be named SIDEA. The tolerance for connections is 0.001 units. Detailed output is requested (see Substructure Command CØMBINE). The basic coordinate system for substructure LEGS is transformed according to transformation set 10 in the Bulk Data.
21,22	Create a new secondary substructure SIDEB which is equivalent to SIDEA. This operation causes image substructures BLEGS and BTABLE to be generated.
23-28	Perform an automatic combination of substructures SIDEA and SIDEB. The resultant combined pseudostructure will be named BIGTABLE. The tolerance for connections is 0.001 units. Detailed output is requested. The basic coordinate system for pseudostructure SIDEB is symmetrically transformed about the XZ plane, identified by Y, the axis normal to the plane (sign change for all 'Y' degrees of freedom).
29-32	Perform a matrix reduction on the matrices of substructure BIGTABLE. The resultant reduced pseudostructure will be named SMALTABL. The retained degrees of freedom are selected in boundary set 100 in the Bulk Data. Detailed output is requested.
33	Print the SØF table of contents.

Table 25. Comments for Phase 2 Data Deck (continued).

Card No.	Refer to Table 24 for input cards described below.
34	Plot pseudostructure SMALTABL. The plot control cards in the Case Control Deck are referenced.
35	Perform a static solution of pseudostructure SMALTABL. The constraint sets and loads selected in the Case Control Deck are used.
36-38	Recover the displacements of substructures BIGTABLE and BTABLE from the solution of SMALTABL and save them on the SØF. Also, print the results for substructure BIGTABL. The output requests in the Case Control Deck are referenced when the PRINT subcommand is invoked.
39	Print the SØF table of contents.
40	End of the Substructure Control Deck.
42-44	Case Control output requests. Referenced by the PRINT subcommand of the RECØVER command.
45-49	Constraint and load set selections are referenced by the SØLVE command.
50-52	Plot control cards are referenced by the PLØT command.
54-58	These Bulk Data cards define the boundary set of retained degrees of freedom which was selected in the REDUCE operation (cards 29-32).
59-64	These cards define the loads and constraints selected in the Case Control Deck for the substructure SØLVE operation.
65,66	These cards define the transformation which is applied to the basic coordinate system of substructure LEGS in the first CØMBINE operation (cards 15-20).

Table 26. Phase 3 Data Deck

```
NASTRAN   FILES = ØPTP
ID        TABLE,BASIC
APP       DISP,SUBS
SØL       1,0
TIME      1
RESTART   TABLE,BASIC (Restart dictionary deck)
CEND
SUBSTRUCTURE PHASE3
PASSWØRD = PRØJECTX
SØF(1) = SØF1,250    $ CDC
BRECØVER BTABLE
ENDSUBS
TITLE = PHASE THREE FØR REFLECTED TABLE
DISP = ALL
ØLØAD = ALL
SPCF = ALL
STRESS = ALL
SUBCASE 1
LØAD = 2
SUBCASE 2
BEGIN BULK
ENDDATA
```

Table 27. Comments for Phase 3 Data Deck.

Card No.	Refer to Table 26 for input cards described below.
1-6	Standard NASTRAN Executive Control Deck except the 'SUBS' option is selected on the APP DISP card. "Card" 5 is actually the Restart deck punched out in Phase 1 for substructure TABLE.
7	First card of the Substructure Control Deck. Phase 3 is selected.
8,9	These cards specify the same SØF used in Phase 2.
10	This card causes the data for the image basic substructure BTABLE to be copied from the SØF to GINØ data blocks. The data can then be used for data recovery operations, i.e., deformed structure plots, stresses, etc.
11	End of Substructure Control Deck.
13-16	Output requests for Phase 3 data recovery.
17-19	The subcase definitions in Phase 3 must be identical to those used in the SØLVE operation in Phase 2. SPC and MPC constraints in Phase 3 must be the same as those used in Phase 2. Load sets selected in Phase 3 must correspond to those selected in Phase 2 for each subcase. However, load sets selected in Phase 2 which do not exist for this particular or basic substructure can not be selected in Phase 3. See Section 1.10.2.5 for a more detailed discussion of the Phase 3 Case Control Deck.

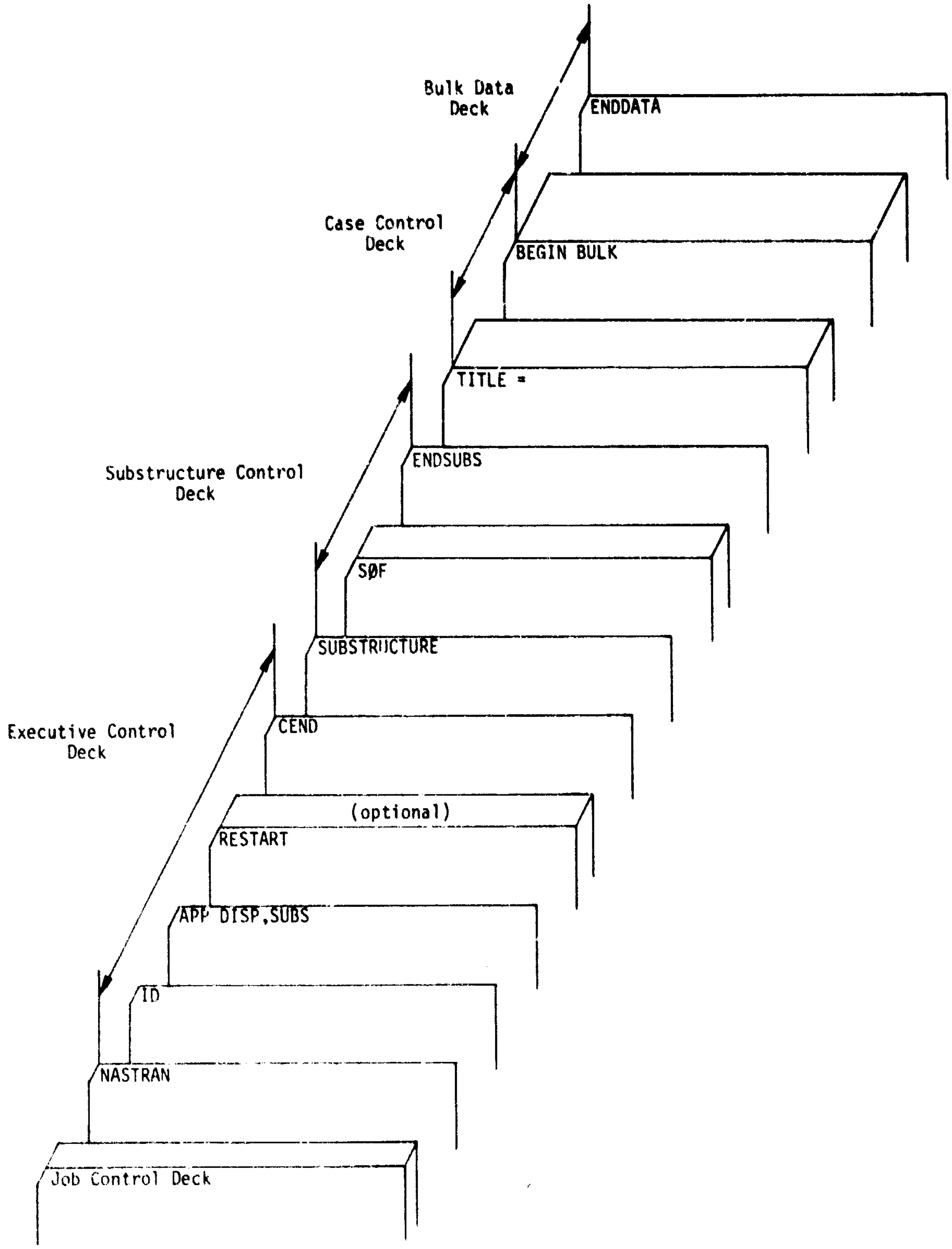


Figure 2. Substructuring input data deck.

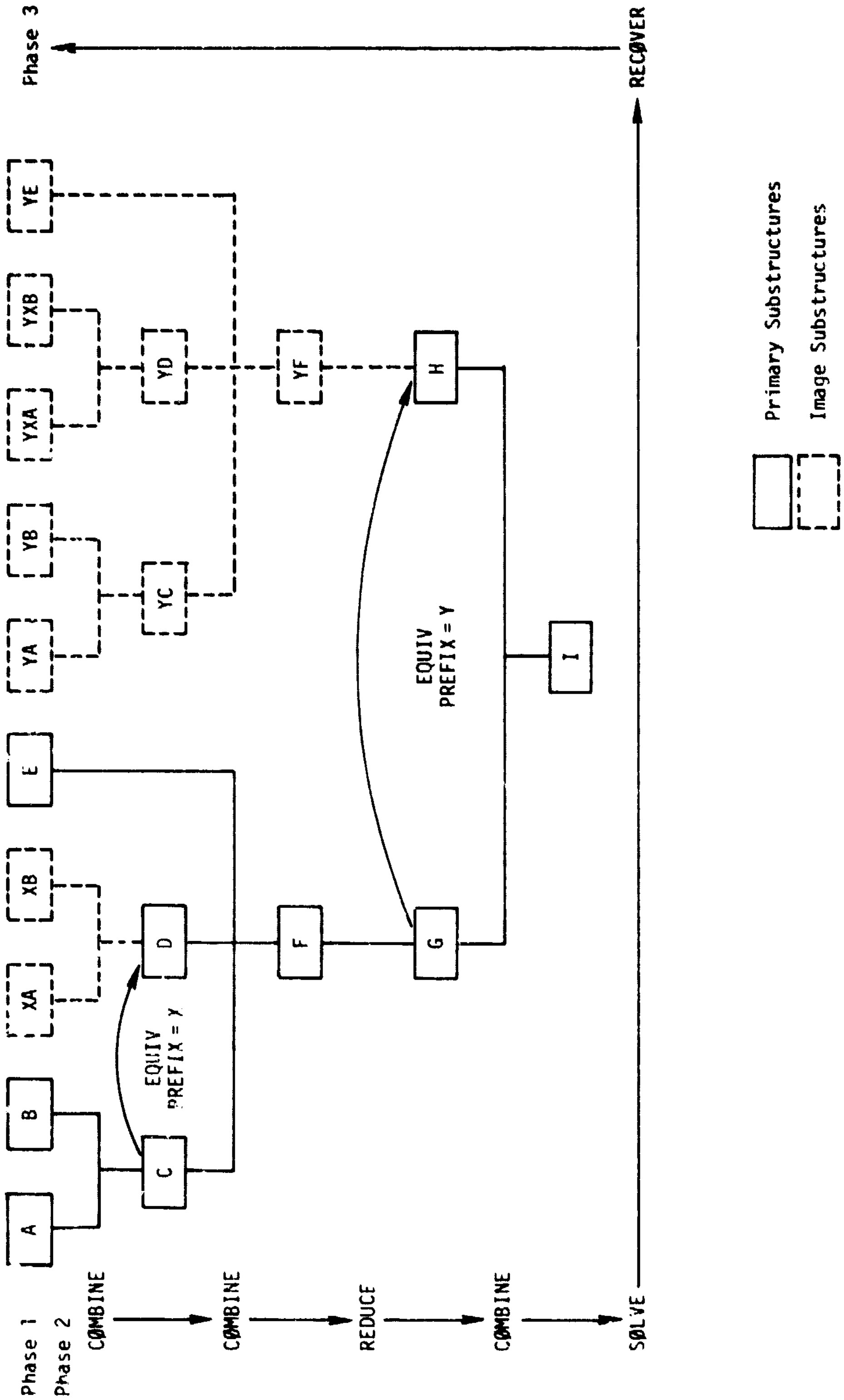


Figure 3. Example of multi-stage substructuring.

S U B S T R U C T U R E Ø P E R A T I N G F I L E T A B L E Ø F C Ø N T E N T S

SUBSTRUCTURE NØ.	NAME	IS	SS	PS	LL	CS	HL	ITEMS									
1	VANE	0	5	0	0	3	6	EQSS	BGSS	LØDS		KMTX	MMTX	PVEC	HØRG	UVEC	
2	RING	0	0	0	0	1	6	EQSS	BGSS	LØDS		KMTX	MMTX	PVEC	HØRG	UVEC	
3	VANER	0	0	1	0	4	6	EQSS	BGSS	LØDS		KMTX	MMTX	PVEC	HØRG		
4	VANEB	0	3	1	0	5	6	EQSS	BGSS	LØDS		KMTX	MMTX	PVEC	HØRG		
5	VANEL	0	4	1	0	2	6	EQSS	BGSS	LØDS		KMTX	MMTX	PVEC	HØRG		
6	WINDMILL	0	0	0	2	0	0	EQSS	BGSS	LØDS	PLTS	KMTX	MMTX	PVEC		UVEC	QVEC

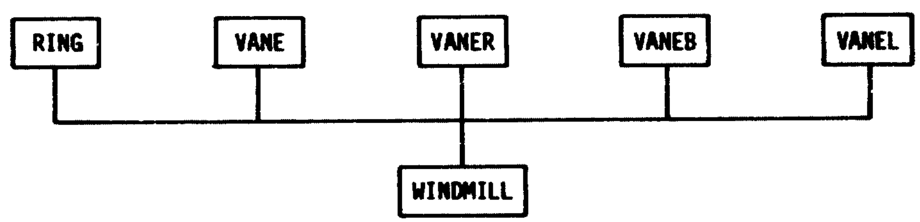
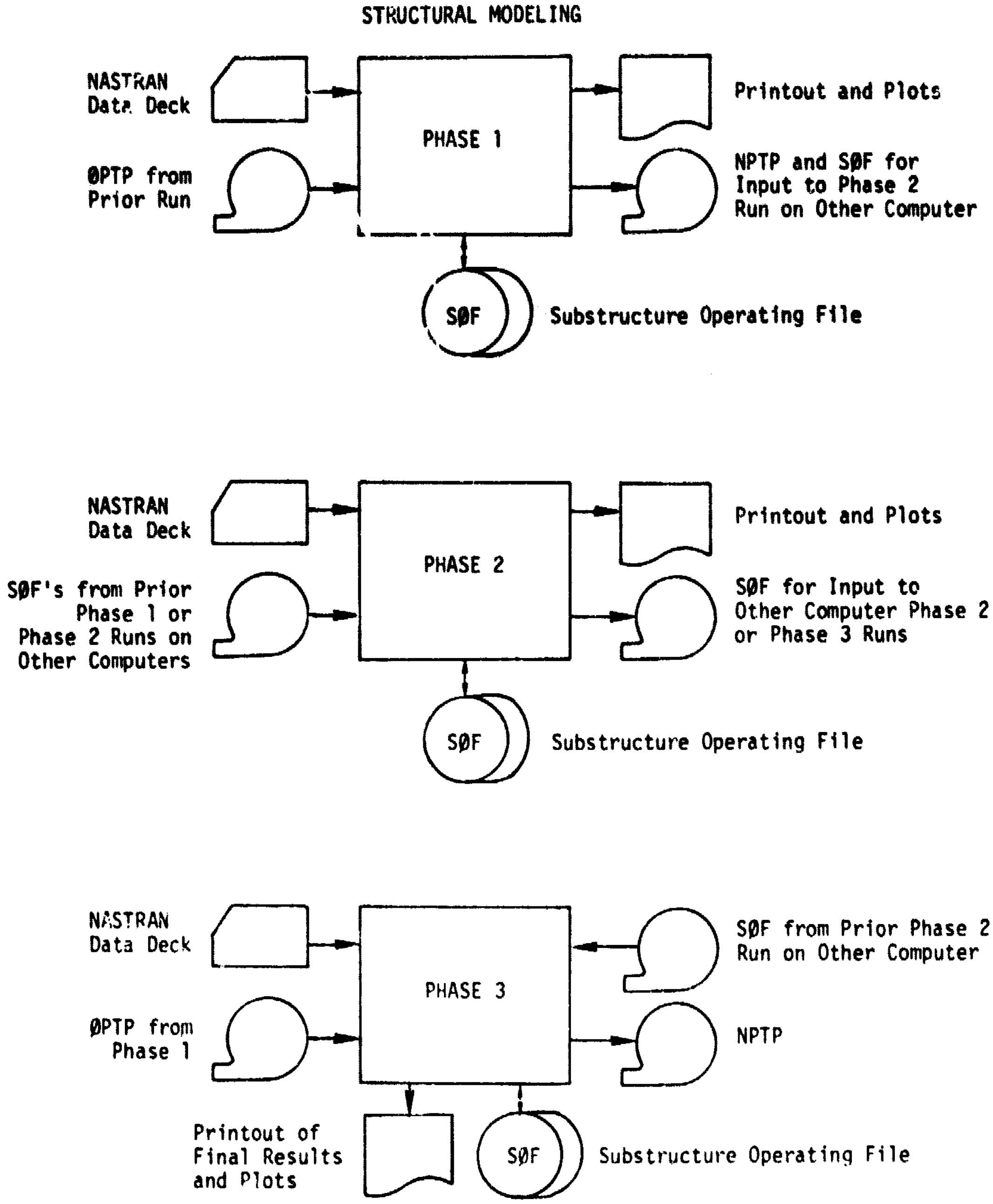
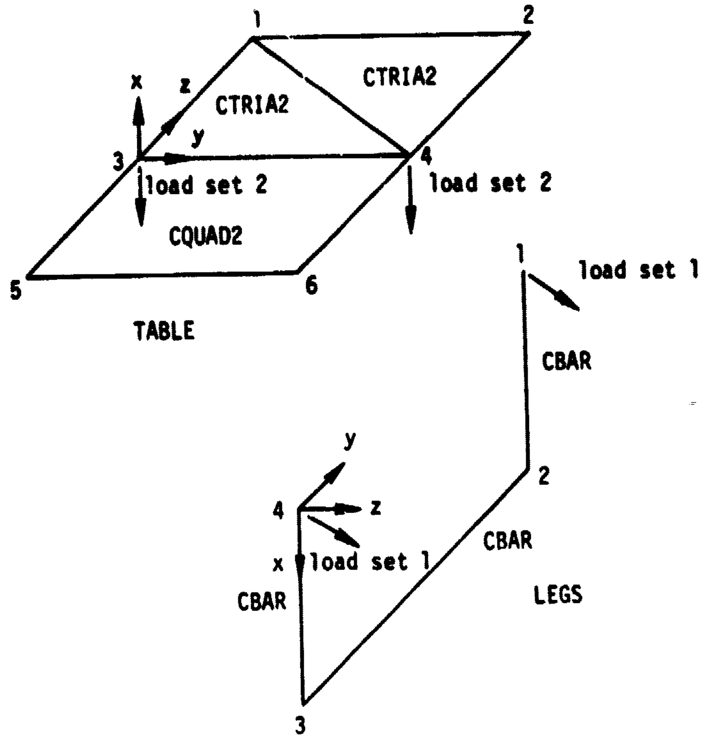


Figure 4. Sample of substructure operating file table of contents.

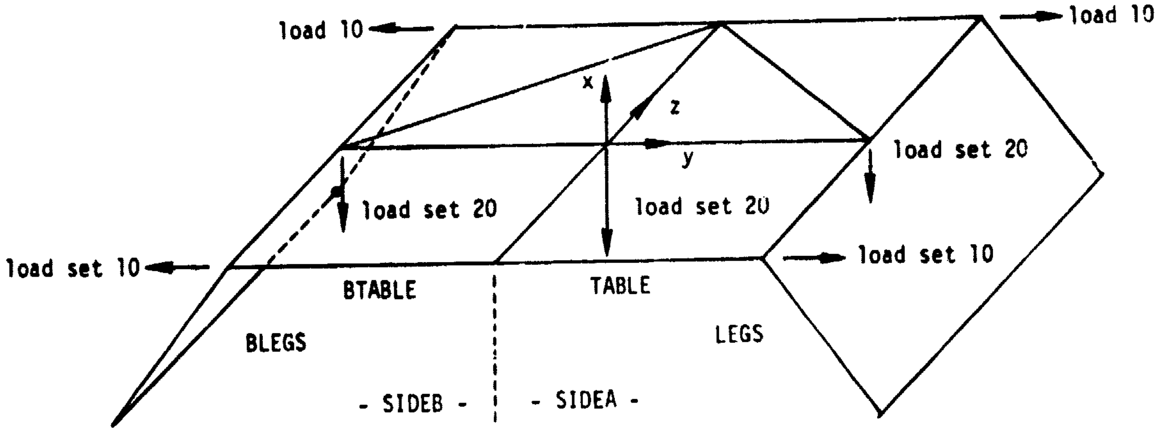


Note: If all processing is performed on the same computer, SØF tape output is not required. All communication may be carried out using the same SØF disk/drum throughout.

Figure 5. Data file organization for NASTRAN multi-stage substructuring.



(a). Phase 1 basic substructures.



(b). Phase 2 combined substructure.

Figure 6. Substructure example problem.

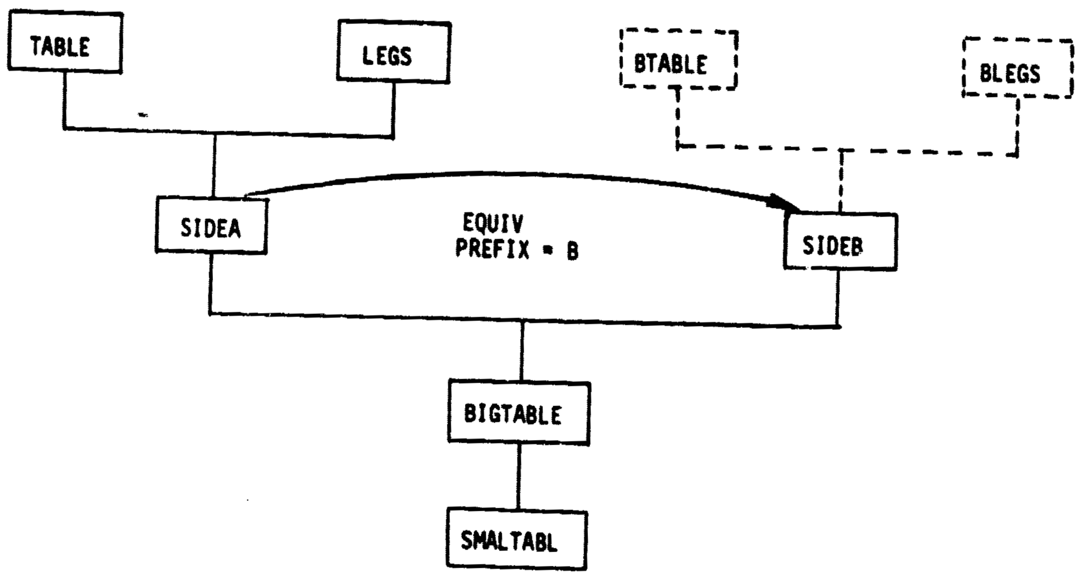


Figure 7. Resultant substructure tree from Phase 2 run.

```
$ AERODYNAMIC ELEMENTS
CAERO1  101     1       1       6       4                       1       +CA101
+CA101  -1.     -.26795 0.      2.0706  -1.     5.45205 0.      2.0706
PAERO1  1
SPLINE2 100     101     101     124     100     0.      1.      1       +SP
+SP     0.      0.
SET1    100     1       THRU    11
$
$ CONTROL DATA
EIGR    10      GIV     .3      .1              6                       +ER
+ER     MAX
PARAM   LMODES  3
AERO    0       1.3+4   2.0706  1.145-7
MKAERO1 .45                                                             +MK
                        .
FLUTTER 30      K       1       2       3       L       3
FLFACT  1       .967
FLFACT  2       .45
FLFACT  3       .2      .16667  .14286  .125    .11111  .1
EIGC    20      HESS    MAX                                             +EC
+EC                                                     3
ENDDATA
```

Figure 4. NASTRAN deck for fifteen degree sweep model (continued).

system for the grid points will be in the swept back system. Twenty-four aerodynamic boxes will be used. The deflections of the aerodynamic boxes will be interpolated using a linear spline.

The Executive Control Deck (from ID to CEND) selects the modal flutter analysis, e.g., APP and SØL cards. A time estimate (CPU min.) is required. The three card ALTER package (not required) will print the nonzero components of the mode shapes of the structure; the mode frequencies are an automatic output of this Rigid Format. If desired, the problem can be checkpointed using modal analysis (Rigid Format 3), and then restarted in flutter analysis (Rigid Format 10), allowing better output format of mode shapes.

The Case Control Deck is used to select constraints, methods, and output. In this problem, SPC set 1 is used to cantilever the root of the beam, and no MPC's are used. A METHØD card must be used to select an EIGR data card for real eigenvalue extraction. An FMETHØD card must select a FLUTTER data card for flutter analysis. A CMETHØD card must select an EIGC control for complex eigenvalue analysis. If desired solution set (SDISP gives modal quantities) or physical set (DISP, STRESS, etc.) output may be requested, but this is not usually done. An automatic flutter summary is printed unless parameter PRINT is set to NØ. The XYØUT request shown will plot V-g and V-f split frame "plots" on the printer output. To produce plots, it is necessary to specify a plotter, request a plot tape, and specify XYPLØT VG. The "curves" (e.g., 1 through 6 in the example) refer to the loops of flutter analysis.

The geometry and constraint bulk data is discussed in previous sections of this manual, and there are no special rules for aeroelastic problems. The structural elements are BAR elements with MASS2 used for torsional inertia. The CØUPMASS option is used to provide a nonsingular mass matrix so that the Given's method of eigenvalue extraction can be used. The bending moment of inertia and torsional rigidity (on the PBAR data card) have been adjusted to match experimental mode frequencies.

The aerodynamic boxes are defined by the CAERØ1 data card. The element number (e.g., 101) becomes the ID of the lowest numbered box. Other boxes are numbered as shown in Figure 3. A property card must be referenced. The leading edge corners of the panel will be specified in coordinate system 1 for this example; however, any defined system may be used. Since equal box sizes are desired, the <u>N</u>SPAN and <u>N</u>CHØRD options are used to specify the <u>n</u>umbers. If unequal divisions were desired, <u>L</u>SPAN and <u>L</u>CHØRD would be used to specify <u>l</u>ists referenced on AEFACT data cards.

MATERIAL PREVIOUSLY FOUND IN SECTION 1.14
HAS BEEN MERGED INTO SECTION 1.10.

2. NASTRAN DATA DECK

2.1 GENERAL DESCRIPTION OF DATA DECK

The input deck begins with the required resident operating system control cards. The type and number of these cards will vary with the installation. Instructions for the preparation of these control cards should be obtained from the programming staff at each installation.

The operating system control cards are followed by the NASTRAN Data Deck (see Figure 1), which is constructed in the following order (depending on the particular job requirements):

1. The NASTRAN Card
2. The Executive Control Deck
3. The Substructure Control Deck
4. The Case Control Deck
5. The Bulk Data Deck
6. The INPUT Module Data Card(s)

The NASTRAN card is used to change the default values for certain operational parameters, such as buffer size and machine model number. The NASTRAN card is optional, but, if present, it must be the first card of the NASTRAN Data Deck. The NASTRAN card is a free-field card (similar to cards in the Executive Control Deck). Its format is as follows:

NASTRAN keyword_1 = value, keyword_2 = value, . . .

The most frequently used keywords are as follows:

1. BUFFSIZE - Defines the number of words in a GINØ buffer. Usually this value is standardized at any particular installation. However, the desired value may be different from the default value of 1803 (IBM), 1183 (CDC) and 1795 (UNIVAC). In any event, related runs, such as restarts and User Master File runs, must use the same BUFFSIZE for all parts of the runs.

2. CØNFIG - Defines the model number of the configuration for use in timing equations for matrix operations. Entries exist for the following configurations:

MACHINE	CØNFIG	MØDEL NØ.
IBM 360	0 (default)	91, 95
	3	50
	4	65
	5	75
	6	85
	7	195

MACHINE	CØNFIG	MØDEL NØ.
IBM 370 (no default)	9	155
	10	165
	11	145
	12	158
	13	168
CDC 6000 (no default)	6	6400/6500
	16	6600
CDC CYBER 170	0 (default)	175
	12	174
	14	173
	15	176
UNIVAC 1100	0 (default)	1110
	14	1108

The machine type is automatically determined by NASTRAN. If the model number is the default, the CØNFIG keyword is not needed on the NASTRAN card. It is important to indicate the proper configuration; otherwise, all time-dependent matrix decisions will be incorrect.

3. MØDCØM(i) - Defines a nine-word array for module communications. Currently, only MØDCØM(1) is supported. If MØDCØM(1) = 1, diagnostic statistics from subroutine SDCØMP are printed; if -1, time and core estimates for module SDCMPS are made without doing the decomposition.
4. HICØRE - Defines the amount of open core available to the user on the UNIVAC 1100 series machines. The user area default is nominally 65K decimal words. The ability to increase this value may be installation limited.
5. TRACKS - Establishes the format for the number of tracks (7 or 9) required for the NASTRAN permanent plot file which will be copied to tape. This parameter is not required if a physical plot tape is used since system control cards define the tracks. The parameters TRACKS = 7, FILES = PLT2 cause plot data to be written to a disk file formatted for a plotter that reads 7-track tapes.
6. FILES - Establishes NASTRAN permanent files as being disk files rather than tape files. The FILES are PØØL, ØPTP, NPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1, INP2, ... INP9. Multiple file names must be enclosed with parentheses such as FILES = (UMF,NPTP). The FILES parameter(s) must be last on the NASTRAN card. Note the plot files, PLT1 and PLT2, cannot be copied from disk to tape on the UNIVAC, therefore a physical tape must be assigned prior to job execution if plotting from disk is not available.
7. STST - Defines the singularity tolerance in EMG and SMA1. The default value is .01. Singularities are written to GPST or (if altered into the Rigid Format) GPSPC. If module

GPSPC is used, it may, on option, automatically constrain the strongest singularity (weakest stiffness) combination.

Additional information for all NASTRAN card options is given in Section 6.3.1 of the Programmer's Manual.

The Executive Control Deck begins with the NASTRAN ID card and ends with the CEND card. It identifies the job and the type of solution to be performed. It also declares the general conditions under which the job is to be executed, such as, maximum time allowed, type of system diagnostics desired, restart conditions, and whether or not the job is to be checkpointed. If the job is to be executed with a rigid format, the number of the rigid format is declared along with any alterations to the rigid format that may be desired. If Direct Matrix Abstraction is used, the complete DMAP sequence must appear in the Executive Control Deck. The executive control cards and examples of their use are described in Section 2.2.

The Substructure Control Deck begins with the SUBSTRUCTURE card and terminates with the ENDSUBS card. It defines the general attributes of the Automated Multi-stage Substructuring capability and establishes the control of the Substructure Operating File (SØF). The command cards are illustrated in Section 2.7.

When Automated Multi-stage Substructuring is not included, then the Case Control Deck begins with the first card following CEND and ends with the card, BEGIN BULK. It defines the subcase structure for the problem, makes selections from the Bulk Data Deck, and makes output requests for printing, punching and plotting. A general discussion of the functions of the Case Control Deck and a detailed description of the cards used in this deck are given in Section 2.3. The special requirements of the Case Control Deck for each rigid format are discussed in Section 3.

The Bulk Data Deck begins with the card following BEGIN BULK and ends with the card preceeding ENDDATA. It contains all of the details of the structural model and the conditions for the solution. The BEGIN BULK and ENDDATA cards must be present even though no new bulk data is being introduced into the problem or all of the bulk data is coming from an alternate source, such as User's Master File or user generated input. The format of the BEGIN BULK card is free field. The ENDDATA card must begin in column 1 or 2. Generally speaking, only one structural model can be defined in the Bulk Data Deck. However, some of the bulk data, such as cards associated with loading conditions, constraints, direct input matrices, transfer functions and thermal

fields may exist in multiple sets. All types of data that are available in multiple sets are discussed in Section 2.3.1. Only sets selected in the Case Control Deck will be used in any particular solution.

If the INPUT module is employed, one or two additional FØRTRAN data cards are required following the ENDDATA card. For specific cases, see Section 2.6.

Comment cards may be inserted in any of the parts of the NASTRAN Data Deck. These cards are identified by a $ in column one. Columns 2-72 may contain any desired text.

Except for the IBM 360/370 series, all NASTRAN data cards must be punched using the character set shown in the table below. The EBCDIC character set may be used on the IBM 360/370 series. Any EBCDIC characters are automatically translated into the character set shown in the table below. The EBCDIC character card punch configurations are shown in parenthesis for the five characters that differ from the standard character set.

Character	Card Punch(s)	Character	Card Punch(s)	EBCDIC Punch(s)
blank	blank	N	11-5	
0	0	Ø	11-6	
1	1	P	11-7	
2	2	Q	11-8	
3	3	R	11-9	
4	4	S	0-2	
5	5	T	0-3	
6	6	U	0-4	
7	7	V	0-5	
8	8	W	0-6	
9	9	X	0-7	
A	12-1	Y	0-8	
B	12-2	Z	0-9	
C	12-3	$	11-3-8	
D	12-4	/	0-1	
E	12-5	+	12	(12-6-8)*
F	12-6	-	11	
G	12-7	(	0-4-8	(12-5-8)*
H	12-8	)	12-4-8	(11-5-8)*
I	12-9	'	4-8	(5-8)*
J	11-1	=	3-8	(6-8)*
K	11-2	,	0-3-8	
L	11-3	.	12-3-8	
M	11-4	*	11-4-8	

*IBM 360/370 only.

2.2 EXECUTIVE CONTROL DECK

The format of the Executive control cards is free field. The name of the operation (e.g., CHKPNT) is separated from the operand by one or more blanks. The fields in the operand are separated by commas, and may be up to 8 integers (Ki) or alphanumeric (Ai) as indicated in the following control card descriptions. The first character of an alphanumeric field must be alphabetic followed by up to 7 additional alphanumeric characters. Blank characters may be placed adjacent to separating commas if desired. The individual cards are described in Section 2.2.1 and examples follow in Section 2.2.2.

2.2.1 Executive Control Card Descriptions

ID A1, A2 Required.

A1, A2 -- Any legal alphanumeric fields chosen by the user for problem identification.

RESTART A1, A2, K1/K2/K3, K4, Required for Restart.

A1, A2 -- Fields taken from ID card of previously checkpointed problem.

K1/K2/K3 -- Month/Day/Year that Problem Tape was generated.

K4 -- Number of seconds after midnight at which XCSA begins execution.

The complete restart dictionary consists of this card followed by one card for each file checkpointed. The restart dictionary is automatically punched when operating in the checkpoint mode. All subsequent cards are continuations of this logical card.

Each continuation card begins with a sequence number. Each type of continuation card will be documented separately.

1. Basic continuation card

   NO,DATABLØCK,FLAG=Y,REEL=Z,FILE=W

   where: NO is the sequence number of the card. The entire dictionary must be in sequence by this number.

   DATABLØCK is the name of the data block referenced by this card.

   FLAG=Y defines the status of the data block where Y = 0 is the normal case and Y = 4 implies this data block is equivalenced to another data block. In this case (FLAG=4) the file number points to a previous data block which is the "actual" copy of the data.

REEL=Z specifies the reel number as the Problem Tape can be a multi-reel tape. Z = 1 is the normal case.

FILE=W specifies the GINØ (internal) file number of the data block on the Problem Tape. A zero value indicates the data block is purged. For example:

1,GPL,FLAGS=0,REEL=1,FILE=7 says data block GPL occupies file 7 of reel 1.

2,KGG,FLAGS=4,REEL=1,FILE=20 says KGG is equivalenced to the data block which occupies file 20. (Note that FLAGS=4 cards usually occur in at least pairs as the equivalenced operation is at least binary).

3,USETD,FLAGS=0,REEL=1,FILE=0 implies USETD is purged.

2. Reentry point card:

NO,REENTER AT DMAP SEQUENCE NUMBER N

where: NO is the sequence number of the card.

N is the sequence number associated with the DMAP instruction at which the problem will restart. This value may be changed by adding a final such card (i.e., only the last such card is operative). This may be necessary when restarting from a Rigid Format to a DMAP sequence (to print a matrix for example).

There are four types of restarts Unmodified Restart, Modified Restart, Rigid Format Switch and Pseudo Modified Restart. The function of the reentry point is different in each case. On an unmodified restart the program continues from the reentry point. On a modified restart modules which must be run to process the modified data but which are ahead of the reentry point are executed first. The program then continues from the reentry point. On a Rigid Format Switch (going from a Rigid Format to another) the reentry point is meaningless in that it was determined for another DMAP sequence. In this case the data blocks available are consulted to determine the proper sequence of modules to run. A Pseudo modified restart (defined by the existence of only changes to output producing data such as plotter requests) is treated like a modified restart. The type of restart is implied by the changes made in the NASTRAN Data Deck. No explicit request for a particular kind of restart is required. See Section 3.1 for additional information. In general, a restart cannot be accomplished from a checkpoint tape created on a previous NASTRAN level. This is primarily due to changes in the Rigid Formats which destroys the validity of the restart dictionary.

3. End of dictionary card

   $ END ØF CHECKPØINT DICTIØNARY

This card is simply a comment card but is punched to signal the end of the dictionary for user convenience. The program does not need such a card. Terminations associated with non-NASTRAN failures (operator intervention, maximum time, etc.) will not have such a card punched.

NUMF K1, K2 Required when creating a User's Master File.

K1 -- User specified tape identification number assigned during the creation of a User's Master File.

K2 -- User specified problem identification number assigned during the creation of a User's Master File.

UMF K1, K2 Required when using a User's Master File.

K1 -- Previously assigned tape identification number to access a Bulk Data Deck when using a User's Master File.

K2 -- Previously assigned problem identification number to access a Bulk Data Deck when using a User's Master File.

CHKPNT A1 or CHKPNT A1, A2 Optional.

A1 -- YES if problem is to be checkpointed, NØ if problem is not to be checkpointed - default is NØ.

A2 -- DISK if checkpoint file is on direct access device. If the DISK option is used, the user must instruct the resident operating system to permanently catalog the checkpoint file.

APP A Required.

A -- DISPLACEMENT indicates one of the Displacement Approach rigid formats.

A -- DISPLACEMENT, SUBS indicates Automated Multi-stage Substructuring with one of the Displacement Approach rigid formats.

A -- HEAT indicates one of the Heat Transfer Approach rigid formats.

A -- AERØ indicates one of the Aeroelastic Approach rigid formats.

A -- DMAP indicates Direct Matrix Abstraction Program (DMAP) Approach.

A -- DMAP, SUBS indicates Direct Matrix Abstraction Program (DMAP) Approach which includes Automated Multi-stage Substructuring modules.

ALTER K1, K2 Optional.

K1, K2 -- First and last DMAP instructions of series to be deleted and replaced with any following DMAP instructions.

ALTER K Optional.

K -- Input any following DMAP instructions after statement K.

ENDALTER Required when using ALTER.

Indicates end of DMAP alterations.

EXECUTIVE CONTROL DECK

TIME K Required.

K -- Maximum allowable execution time in minutes.

SØL K1 [,Ki] or SØL An [,Ki] Required when using a rigid format (see Section 3.1 for available options).

K1 -- Solution number of Rigid Format (see table below and Section 3.1).

Ki -- Subset numbers for solution K1, default value = 0. Multiple subsets may be selected by using multiple integers separated by commas.

An -- Name of Rigid Format (see table below)

Displacement Approach Rigid Formats

K1	An
1	STATICS
2	INERTIA RELIEF
3	MØDES or NØRMAL MØDES or REAL EIGENVALUES
4	DIFFERENTIAL STIFFNESS
5	BUCKLING
6	PIECEWISE LINEAR
7	DIRECT CØMPLEX EIGENVALUES
8	DIRECT FREQUENCY RESPØNSE
9	DIRECT TRANSIENT RESPØNSE
10	MØDAL CØMPLEX EIGENVALUES
11	MØDAL FREQUENCY RESPØNSE
12	MØDAL TRANSIENT RESPØNSE
13	NØRMAL MØDES ANALYSIS WITH DIFFERENTIAL STIFFNESS
14	STATICS CYCLIC SYMMETRY
15	MØDES CYCLIC SYMMETRY

Heat Transfer Approach Rigid Formats

K1	An
1	STATICS
3	STEADY STATE
9	TRANSIENT

Aeroelastic Approach Rigid Formats

K1	An
10	MØDAL FLUTTER ANALYSIS
11	MØDAL AERØELASTIC RESPØNSE

Ki	Subset Numbers
1	Delete loop control.
2	Delete mode acceleration method of data recovery (modal transient and modal frequency response).
3	Combine subsets 1 and 2.
4	Check all structural and aerodynamic data without execution of the aeroelastic problem.
5	Check only the aerodynamic data without execution of the aeroelastic problem.
6	Delete checkpoint instructions.
7	Delete structure plotting and X-Y plotting.
8	Delete Grid Point Weight Generator.
9	Delete fully stressed design (static analysis).

DIAG K Optional request for diagnostic output.

K = 1 Dump memory when fatal message is generated.

K = 2 Print File Allocation Table (FIAT) following each call to the File Allocator.

K = 3 Print status of the Data Pool Dictionary (DPD) following each call to the Data Pool Housekeeper.

K = 4 Print the Operation Sequence Control Array (ØSCAR).

K = 5 Print BEGIN time on-line for each functional module.

K = 6 Print END time on-line for each functional module.

K = 7 Print eigenvalue extraction diagnostics for real and complex determinant methods.

K = 8 Print matrix and table data block trailers as they are generated.

K = 9 Suppress echo of checkpoint dictionary.

K = 10 Use alternate nonlinear loading in TRD. (Replace $\{N_{n+1}\}$ by $\frac{1}{3}\{N_{n+1} + N_n + N_{n-1}\}$)

K = 11 Print all active row and column possibilities for decomposition algorithms.

K = 12 Print eigenvalue extraction diagnostics for complex inverse power or FEER methods.

K = 13 Print open core length.

K = 14 Print the Rigid Format (NASTRAN SØURCE PRØGRAM CØMPILATION)

K = 15 Trace GINØ ØPEN/CLØSE operations.

K = 16 Trace real inverse power eigenvalue extraction operations or eigensolution diagnostics for FEER tridiagonalization.

K = 17 Punch the DMAP sequence that is compiled.

K = 18 Trace Heat Transfer iterations (APP HEAT) or print grid point ID conversions from SET2 card (APP AERØ).

K = 19 Print data for MPYAD method selection.

K = 20 Generate de-bug printout (For NASTRAN programmers who include CALL BUG in their subroutines).

K = 21 Print GP4 set definition.

K = 22 Print GP4 degree of freedom definition.

K = 23 Print the DMAP alters generated during Automated Multi-stage Substructuring.

K = 24 Punch the DMAP alters generated during Automated Multi-stage Substructuring.

K = 25

K = 26

K = 27 Input File Processor (IFP) table dump.

K = 28 Punch the link specification table (Deck XBSBD).

K = 29 Process link specification table update deck.

K = 30   Punch alters to the XSEMi decks (i set via DIAG 1-15).

K = 31   Print link specification table and module properties list data.

Multiple options may be selected by using multiple integers separated by commas. Other options and other rules associated with the DIAG card, which primarily concern the programmer, can be found in Section 6.11.3 of the Programmer's Manual.

BEGIN$ Required when using DMAP approach.

Indicates the beginning of a DMAP sequence. This card is supplied as part of a Rigid Format.

END$ Required when using DMAP approach.

Indicates the end of a DMAP sequence. This card is supplied as part of a Rigid Format. The END$ statement cannot be ALTERed into a Rigid Format at intermediate steps. To schedule an early termination, use either the EXIT$ statement or the JUMP, FINIS$ statement.

<u>UMFEDIT</u>   Required when using User's Master File Editor (see Section 2.5).

<u>$</u>   Comment flag in column 1. Commentary text may appear in columns 2-80.

<u>CEND</u> Required

Indicates end of Executive control cards.

The ID card must appear first and CEND must be the last card of the Executive Control Deck. Otherwise the Executive Control card groups (RESTART dictionary, DMAP sequence, ALTER packet) can be in any order.

2.2.2 Executive Control Deck Examples

1. Cold start, no checkpoint, rigid format, diagnostic output.

```
ID          MYNAME, BRIDGE23
APP         DISPLACEMENT
SØL         2,0
TIME        5
DIAG        1,2
CEND
```

2. Cold start, checkpoint, rigid format.

```
ID          PERSØNZZ, SPACECFT
CHKPNT      YES
APP         DISPLACEMENT
SØL         1,3
TIME        15
CEND
```

3. Restart, no checkpoint, rigid format. The restart dictionary indicated by the brace is automatically punched on previous run in which the CHKPNT option was selected by the user.

```
ID JØESHMØE, PRØJECTX
RESTART  PERSØNZZ, SPACECFT, 05/13/67, 18936,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0 REEL=1, FILE=7
                    .
                    .
                    .

$ END OF CHECKPØINT DICTIØNARY
APP           DISPLACEMENT
SØL           3,3
TIME          10
CEND
```

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4. Cold start, no checkpoint, DMAP. User-written DMAP program is indicated by braces.

```
ID          IAM007, TRYIT
APP         DMAP
BEGIN $

{DMAP statements go here}

END $
TIME        8
CEND
```

5. Restart, checkpoint, altered rigid format, diagnostic output.

```
ID BEAM, FIXED
RESTART BEAM, FREE, 05/09/68, 77400,
     1, XVPS, FLAGS=0, REEL=1, FILE=6
     2, REENTER AT DMAP SEQUENCE NUMBER 7
     3, GPL, FLAGS=0, REEL=1, FILE=7
                    .
                    .
                    .
$ END ØF CHECKPØINT DICTIØNARY
CHKPNT      YES
DIAG        2,4
APP         DISPLACEMENT
SØL         3,3
TIME        15
ALTER       20
MATPRN      KGGX,,,,// $
TABPT       GPST,,,,// $
ENDALTER
CEND
```

2.3 CASE CONTROL DECK

2.3.1 Data Selection

The Case Control cards that are used for selecting items from the Bulk Data Deck are listed below in functional groups. A detailed description of each card is given in Section 2.3.4. The first four characters of the mnemonic are sufficient if unique.

The following Case Control cards are associated with the selection of applied loads for both static and dynamic analysis:

1. DEFØRM - selects element deformation set.
2. DLØAD - selects dynamic loading condition.
3. DSCØEFFICIENT - selects loading factor for normal modes with differential stiffness.
4. LØAD - selects static structural loading condition or heat power and/or flux.
5. NØNLINEAR - selects nonlinear loading condition for transient response.
6. PLCØEFFICIENT - selects loading increments for piecewise linear analysis.

The following case control cards are used for the selection of constraints:

1. AXISYMMETRIC - selects boundary conditions for conical shell and axisymmetric solid elements or specifies the existence of fluid harmonics for a hydroelastic problem.
2. MPC - selects set of multipoint constraints for structural displacement or heat transfer boundary temperature relationships.
3. SPC - selects set of single-point constraints for structural displacements or heat transfer boundary temperatures.

The following case control cards are used for the selection of direct input matrices:

1. B2PP - selects direct input structural damping or thermal capacitance matrices.
2. K2PP - selects direct input structural stiffness or thermal conductance matrices.
3. M2PP - selects direct input mass matrices.
4. TFL - selects transfer functions.

The following case control cards specify the conditions for dynamic analyses:

1. CMETHØD - selects the conditions for complex eigenvalue extraction.
2. FREQUENCY - selects the frequencies to be used for frequency and random response calculations.
3. IC - selects the initial conditions for direct transient response.
4. METHØD - selects the conditions for real eigenvalue analysis.
5. RANDØM - selects the power spectral density functions to be used in random analysis.

6. SDAMPING - selects table to be used for determination of modal damping.

7. TSTEP - selects time steps to be used for integration in transient response problems.

8. FMETHØD - selects method to be used in aeroelastic flutter analysis.

The following case control cards are associated with the use of thermal fields:

1. TEMPERATURE(LØAD) - selects thermal field to be used for determining equivalent static loads.

2. TEMPERATURE(MATERIAL) - selects thermal field to be used for determining structural material properties or an estimate of the temperature distribution for heat transfer iterations.

3. TEMPERATURE - selects thermal field for determining both equivalent static loads and material properties.

2.3.2 Output Selection

Printer output requests may be grouped in packets following ØUTPUT cards or the individual requests may be placed anywhere in the Case Control Deck ahead of any structure plotter or curve plotter requests. Plotter requests are described in Section 4. The Case Control cards that are used for output selection are listed below in functional groups. A detailed description of each card is given in Section 2.3.4.

The following cards are associated with output control, titling and bulk data echoes:

1. TITLE - defines a text to be printed on first line of each page of output.

2. SUBTITLE - defines a text to be printed on second line of each page of outout.

3. LABEL - defines a text to be printed on third line of each page of output.

4. LINE - sets the number of data lines per printed page, default is 50 for 11-inch paper.

5. MAXLINES - sets the maximum number of output lines, default is 20,000.

6. ECHØ - selects echo options for Bulk Data Deck, default is a sorted bulk data echo.

The following cards are used in connection with some of the specific output requests for calculated quantities:

1. SET - defines lists of point numbers, elemerts numbers, or frequencies for use in output requests.

2. ØFREQUENCY - selects a set of frequencies to be used for output requests in frequency response problems (default is all frequencies) or flutter velocities.

3. TSTEP - selects a set of time steps to be used for output requests in transient response problems.

4. ØTIME - selects a set of times to be used for output requests in transient analysis problems (default is all times).

The following cards are used to make output requests for the calculated response of components in the SØLUTIØN set (components in the direct or modal formulation of the general K system) for dynamics problems:

1. SACCELERATIØN - requests the acceleration of the independent components for a selected set of points or modal coordinates.
2. SDISPLACEMENT - requests the displacements of the independent components for a selected set of points or modal coordinates or the temperatures of the independent components for a selected set of points in heat transfer.
3. SVELØCITY - requests the velocities of the independent components for a selected set of points or modal coordinates or the change in temperature with respect to time of the independent components for a selected set of points in heat transfer.
4. NLLØAD - requests the nonlinear loads for a selected set of physical points (grid points and extra points introduced for dynamic analysis) in transient response problems.

The following cards are used to make output requests for stresses and forces, as well as the calculated response of degrees of freedom used in the model:

1. ELFØRCE - requests the forces in a set of structural elements or the temperature gradients and fluxes in a set of structural or heat elements in heat transfer.
2. STRESS - requests the stresses in a set of structural elements or the velocity components in a fluid element in acoustic cavity analysis.
3. SPCFØRCES - requests the single-point forces of constraint at a set of points or the thermal power transmitted to a selected set of points in heat transfer.
4. ØLØAD - selects a set of applied loads for output.
5. ACCELERATIØN - requests the accelerations for a selected set of PHYSICAL points (grid, scalar and fluid points plus extra points introduced for dynamic analysis).
6. DISPLACEMENT - requests the displacements for a selected set of PHYSICAL points or the temperatures for a selected set of PHYSICAL points in heat transfer or the pressures for a selected set of PHYSICAL points in hydroelasticity.
7. VELØCITY - requests the velocities for a selected set of PHYSICAL points or the change in temperatures with respect to time for a selected set of PHYSICAL points in heat transfer.
8. HARMØNICS - controls the number of harmonics that will be output for requests associated with the conical shell, axisymmetric solids and hydroelastic problems.
9. ESE - requests structural element strain energies in Rigid Format 1.
10. GPFØRCE - requests grid point force balance due to element forces, forces of single point constraint, and applied loads in Rigid Format 1.
11. THERMAL - requests temperatures for a set of PHYSICAL points in heat transfer.
12. PRESSURE - requests pressures for a set of PHYSICAL points in hydroelasticity.
13. VECTØR - requests displacements for a selected set of PHYSICAL points.
14. MPCFØRCES - requests multipoint forces of constraint at a set of points in Rigid Formats 1 and 3.

15. NCHECK - requests significant digits to indicate numerical accuracy of element stress and force computations.

16. AERØFØRCE - requests frequency dependent aerodynamic loads on interconnection points in aeroelastic response analysis.

2.3.3 Subcase Definition

In general, a separate subcase is defined for each loading condition. In statics problems separate subcases are also defined for each set of constraints. In complex eigenvalue analysis and frequency response separate subcases are defined for each unique set of direct input matrices. Subcases may be used in connection with output requests, such as in requesting different output for each mode in a real eigenvalue problem.

The Case Control Deck is structured so that a minimum amount of repetition is required. Only one level of subcase definition is provided. All items placed above the subcase level (ahead of the first subcase) will be used for all following subcases, unless overridden within the individual subcase.

Case Control Data Card DISPLACEMENT - Displacement Output Request.

Description: Requests form and type of displacement vector output.

Format and Example(s):

$$\text{DISPLACEMENT} \left[\left(\begin{matrix} \underline{\text{SØRT1}} \\ \text{SØRT2} \end{matrix}, \begin{matrix} \underline{\text{PRINT}} \\ \text{PUNCH} \end{matrix}, \begin{matrix} \underline{\text{REAL}} \\ \text{IMAG} \\ \text{PHASE} \end{matrix} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

DISPLACEMENT = 5

DISPLACEMENT(REAL) = ALL

DISPLACEMENT(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points will be output.
NØNE	Displacements for no points will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT AND PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 causes all output to be SØRT2.
4. VECTØR, PRESSURE and THERMAL are alternate forms and are entirely equivalent to DISPLACEMENT.
5. DISPLACEMENT = NØNE allows overriding an overall output request.

Case Control Data Card DLØAD - Dynamic Load Set Selection.

Description: Selects the dynamic load to be applied in a Transient or Frequency Response problem.

Format and Example(s):

DLØAD = n

DLØAD = 73

Option	Meaning
n	Set identification of a DLØAD, RLØAD1, RLØAD2, TLØAD1, or TLØAD2 card (Integer > 0).

Remarks:

1. The above loads will not be used by NASTRAN unless selected in Case Control.
2. RLØAD1 and RLØAD2 may only be selected in a Frequency Response problem.
3. TLØAD1 and TLØAD2 may only be selected in a Transient Response problem.
4. Either RLØAD or TLØAD (but not both) may be selected in an Aeroelastic Response problem. If RLØAD is selected, a Frequency Response is calculated. If TLØAD is selected, then Transient Response is computed by Fourier Transform.

Case Control Data Card DSCØEFFICIENT - Differential Stiffness Coefficient Set.

Description: Selects the coefficient set for a Normal Modes with Differential Stiffness Problem.

Format and Example(s):

DSCØEFFICIENT = $\left\{ \begin{matrix} \text{DEFAULT} \\ \text{n} \end{matrix} \right\}$

DSCØEF = 15

DSCØEF = DEFAULT

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of DSFACT card (Integer > 0).

Remarks:

1. DSFACT cards will not be used unless selected.
2. DSCØEFFICIENT must appear in the 2nd Subcase of a Normal Modes with Differential Stiffness problem.

Case Control Data Card <u>ECHØ</u> - Bulk Data Echo Request.

<u>Description</u>: Requests echo of bulk data deck.

<u>Format and Example(s)</u>:

$$\text{ECHØ} = \begin{bmatrix} \underline{\text{SØRT}} \\ \text{UNSØRT} \\ \text{BØTH} \\ \text{NØNE} \\ \text{PUNCH} \end{bmatrix}$$

ECHØ = BØTH

ECHØ = PUNCH, SØRT

Option	Meaning
SØRT	Sorted echo will be printed.
UNSØRT	Unsorted echo will be printed.
BØTH	Both sorted and unsorted echo will be printed.
NØNE	No echo will be printed.
PUNCH	The sorted bulk data deck will be punched onto cards.

<u>REMARKS</u>:

1. If no ECHØ card appears a sorted echo will be printed.
2. If CHKPNT YES a sorted echo will be printed unless ECHØ = NØNE.
3. Unrecognizable options will be treated as SØRT.
4. Any option overrides the default. Thus, for example, if both print and punch are desired, both SØRT and PUNCH must be requested on the same card.
5. The NØNE option cannot be combined with the PUNCH option. If punch output only is desired, ECHØ = PUNCH will suffice.

Case Control Data Card ELFØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{ELFØRCE}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \begin{matrix}\frac{\text{REAL}}{\text{IMAG}}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

ELFØRCE = ALL

ELFØRCE(REAL, PUNCH, PRINT) = 17

ELFØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for all elements will be output.
NØNE	Forces for no elements will be output.
n	Set identification of a previously appearing SET card. Only forces of elements whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. FØRCE is an alternate form and is entirely equivalent to ELFØRCE.
5. ELFØRCE = NØNE allows overriding an overall request.
6. In heat transfer analysis, ELFØRCE output consists of heat flow through and out of the elements.

Case Control Data Card <u>ELSTRESS</u> - Element Stress Output Request.

Description: Requests form and type of element stress output.

Format and Example(s):

$$\text{ELSTRESS}\quad\left[\left(\begin{matrix}\text{SØRT1}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

ELSTRESS = 5

ELSTRESS = ALL

ELSTRESS(SØRT1, PRINT, PUNCH, PHASE) = 15

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \le$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Stresses for all elements will be output.
n	Set identification of a previously appearing SET card (Integer > 0). Only stresses for elements whose identification numbers appear on this SET card will be output.
NØNE	Stress for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. STRESS is an alternate form and is entirely equivalent to ELSTRESS.
5. ELSTRESS = NØNE allows overriding an overall output request.

Case Control Data Card ESE - Element Strain Energy Output Request

Description: Requests strain energy output and per cent of total strain energy with respect to all elements.

Format and Example(s):

$$\text{ESE} \left[\left(\begin{matrix} \text{PRINT} \\ \hline \text{PUNCH} \end{matrix} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ \text{n} \\ \text{NØNE} \end{matrix} \right\}$$

ESE (PUNCH) = 5

ESE (PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Strain energies will be output for all elements for which stiffness matrices exist.
NØNE	Strain energies for no elements will be output.
n	Set identification of previously appearing SET card (Integer >0). Only strain energies for elements whose identification numbers appear on this SET card will be output.

Remarks:

1. Element strain energies are output from Static Analysis (Rigid Format 1) only.
2. The output will be in SØRT 1 format.
3. Both PRINT and PUNCH may be requested.
4. ESE = NØNE allows overriding an overall output request.

Case Control Data Card FMETHØD -Flutter Analysis Method

Description: Selects the FLUTTER parameters to be used by the flutter module (FA1).

Format and Example(s):

FMETHØD = n
FMETHØD = 72

Option	Meaning
n	Set identification number of a FLUTTER card (integer > 0).

Remarks: 1. A FMETHØD card is required for flutter analysis.

Case Control Data Card FØRCE - Element Force Output Request.

Description: Requests form and type of element force output.

Format and Example(s):

$$\text{FØRCE} \quad \left[\left(\begin{matrix}\text{SØRT1} \\ \text{SØRT2}\end{matrix}, \begin{matrix}\text{PRINT} \\ \text{PUNCH}\end{matrix}, \begin{matrix}\text{REAL} \\ \text{IMAG} \\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL} \\ n \\ \text{NØNE}\end{matrix}\right\}$$

FØRCE = ALL

FØRCE(REAL, PUNCH, PRINT) = 17

FØRCE = 25

Option	Meaning
SØRT1	Output will be presented as a tabular listing of elements for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each element type. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary printout on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Forces for ALL elements will be output.
n	Set identification of a previously appearing SET card. Only forces whose element identification numbers appear on this SET card will be output (Integer > 0).
NØNE	Forces for no elements will be output.

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. ELFØRCE is an alternate form and is entirely equivalent to FØRCE.
5. FØRCE = NØNE allows overriding an overall request.
6. In heat transfer analysis, ELFØRCE output consists of heat flow through and out of the elements.

Case Control Data Card FREQUENCY - Frequency Set Selection

Description: Selects the set of frequencies to be solved in Frequency Response problems.

Format and Example(s):

FREQUENCY = n
FREQUENCY = 17

Option	Meaning
n	Set identification of a FREQ, FREQ1 or FREQ2 type card (Integer > 0).

Remarks:

1. The FREQ, FREQ1 or FREQ2 cards will not be used unless selected in Case Control.
2. A frequency set selection is required for a Frequency Response problem.
3. A frequency set selection is required for Transient Response by Fourier methods.

Case Control Data Card GPFØRCE - Grid Point Force Balance Output Request

Description: Requests grid point force balance output from applied loads, single-point constraints, and element contraints.

Format and Example (s):

$$\text{GPFØRCE} \quad \left[\left(\frac{\text{PRINT}}{\text{PUNCH}}\right)\right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Force balance will be output for all elements connected to grid points or scalar points.
NØNE	Force balance for no grid points will be output.
n	Set identification of previously appearing SET card (Integer >0). Only force balance for points whose identification numbers appear on this SET card will be output.

Remarks:

1. Grid point force balance is output from Statics Analysis (Rigid Format 1) only.
2. The output will be in SØRT 1 format.
3. Both PRINT and PUNCH may be requested.
4. GPFØRCE = NØNE allows overriding an overall output request.

Case Control Data Card <u>HARMØNICS</u> - Harmonic Printout Control.

<u>Description</u>: Controls number of harmonics output for problems containing CCØNEAX, CTRAPAX or CTRIAAX elements.

<u>Format and Example(s)</u>:

$$\text{HARMONICS} = \begin{Bmatrix} \text{ALL} \\ \text{NØNE} \\ n \\ \underline{0} \end{Bmatrix}$$

Option	Meaning
ALL	All Harmonics will be output.
NØNE	No Harmonics will be output.
n	Available harmonics up to and including n will be output (Integer $\geq$ 0).

<u>Remarks</u>: If no HARMØNICS card appears in Case Control, only 0 harmonic output will be printed.

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Case Control Data Card IC - Transient Initial Condition Set Selection.

Description: To select the initial conditions for Direct Transient problems.

Format and Example(s):

IC = n

IC = 17

Option	Meaning
n	Set identification of TIC card (Integer > 0) for structural analysis. Set identification of TEMP and/or TEMPD card (Integer > 0) for heat transfer analysis.

Remarks: 1. TIC cards will not be used (hence no initial conditions) unless selected in Case Control.

2. Initial conditions are not allowed in a Modal Transient problem.

Case Control Data Card K2PP - Direct Input Stiffness Matrix Selection.

Description: Selects a direct input stiffness matrix.

Format and Example(s):

K2PP = name

K2PP = KDMIG

K2PP = K2PP

Option	Meaning
name	BCD name of a $[K^{2d}_{pp}]$ matrix that is input on the DMIG or DMIAX bulk data card.

Remarks: 1. K2PP is used only in dynamics problems.

2. DMIG and DMIAX matrices will not be used unless selected.

Case Control Data Card LABEL - Output Label.

Description: Defines a BCD label which will appear on the third heading line of each page of NASTRAN printer output.

Format and Example(s):

LABEL = { Any BCD data }

LABEL = SAMPLE ØF A LABEL CARD

Remarks: 1. LABEL appearing at the subcase level will label output for that subcase only.

2. LABEL appearing before all subcases will label any outputs which are not subcase dependent.

3. If no LABEL card is supplied, the label line will be blank.

4. LABEL information is also placed on NASTRAN plotter output as applicable.

Case Control Data Card <u>LINE</u> - Data Lines Per Page.

<u>Description</u>: Defines the number of data lines per printed page.

<u>Format and Example(s)</u>:

LINE = $\left\{\begin{matrix}\underline{50}\\ n\end{matrix}\right\}$ IBM or CDC

LINE = $\left\{\begin{matrix}\underline{45}\\ n\end{matrix}\right\}$ UNIVAC

LINE = 35

<u>Option</u>	<u>Meaning</u>
n	Number of data lines per page (Integer > 0).

<u>Remarks</u>:

1. If no LINE card appears, the appropriate default is used.
2. For 11 inch paper, 50 is the recommended number; for 8-1/2 inch paper, 40 is the recommended number.

Case Control Data Card __LØAD__ **- External Static Load Set Selection.**

__Description:__ Selects the external static load set to be applied to the structural model.

__Format and Example(s):__

LØAD = n

LØAD = 15

__Option__	__Meaning__
n	Set identification of at least one external load card and hence must appear on at least one FØRCE, FØRCE1, FØRCE2, MØMENT, MØMENT1, MØMENT2, GRAV, PLØAD, PLØAD2, PLØAD3, RFØRCE, PRESAX, FØRCEAX, MØMAX, SLØAD, or LØAD card (Integer > 0).

__Remarks:__

1. The above static load cards will not be used by NASTRAN [illegible]s selected in Case Control.
2. A GRAV card cannot have the same set identification number as any of the other loading card types. If it is desired to apply a gravity load along with other static loads, a LØAD bulk data card must be used.
3. LØAD is only applicable in statics, inertia relief, differential stiffness, buckling, and piecewise linear problems.
4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) Loads.
5. Static, thermal and element deformation loads must have unique set identification numbers.
6. Each of the rigid formats that accept a static load card expect it to appear in the Case Control Deck in a certain place with respect to subcase definitions. See Section 3 for specific instructions.

Case Control Data Card METHØD - Real Eigenvalue Extraction Method Selection.

Description: Selects the Real Eigenvalue Parameters to be used by the READ module.

Format and Example(s):

METHØD = n

METHØD = 33

Option	Meaning
n	Set identification number of an EIGR card (normal modes or modal formulation) or an EIGB card (Buckling). (Integer > 0)

Remarks:
1. An eigenvalue extraction method must be selected when extracting real eigenvalues using Functional Module READ.
2. Each of the rigid formats that accept an eigenvalue method card expect it to appear in the Case Control Deck in a certain place with respect to subcase definitions. See Section 3 for specific instructions.

Case Control Data Card MØDES - Duplicate Case Control.

Description: Repeats case control MØDES times - to allow control of output in eigenvalue problems.

Format and Example(s):

MØDES = n

MØDES = 1

Option	Meaning
n	Number of modes, starting with the first and proceeding sequentially upward, for which the case control or subcase control is to apply. (Integer > 0).

Remarks: 1. This card can be illustrated by an example. Suppose stress output is desired for the first five modes only and Displacements only thereafter. The following example would accomplish this:

```
SUBCASE 1
MØDES = 5
ØUTPUT
STRESS = ALL
SUBCASE 6
ØUTPUT
DISPLACEMENTS = ALL
BEGIN BULK
```

2. The MØDES card causes the results for each eigenvalue to be considered as a separate, successively numbered subcase, beginning with the subcase number containing the MØDES card.

3. If the MØDES card is not used, eigenvalue results are considered to be a part of a single subcase. Hence, any output requests for the single subcase will apply for all eigenvalues.

4. All eigenvectors with mode numbers greater than the number of records in Case Control are printed with the descriptors of the last Case Control record. For example, to suppress all printout for modes beyond the first three, the following Case Control deck could be used:

```
SUBCASE 1
MØDES = 3
DISPLACEMENTS = ALL
SUBCASE 4
DISPLACEMENTS = NØNE
BEGIN BULK
```

Case Control Data Card MPC - Multipoint Constraint Set Selection.

Description: Selects the multipoint constraint set to be applied to the structural model.

Format and Example(s):

MPC = n

MPC = 17

Option	Meaning
n	Set identification of a Multipoint-Constraint Set and hence must appear on at least one MPC, MPCADD, MPCAX, or MPCS card. (Integer > 0).

Remarks: MPC, MPCADD, MPCAX, or MPCS cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card MPCFØRCES - Multipoint Forces of Constraint Output Request

Description: Requests multipoint force of constraint vector output.

Format and Example(s):

$$\text{MPCFØRCES}\left[\left(\text{SØRT1},\frac{\text{PRINT}}{\text{PUNCH}}\right)\right]=\left\{\begin{array}{c}\text{ALL}\\ \text{n}\\ \text{NØNE}\end{array}\right\}$$

MPCFØRCE = 10

MPCFØRCE(PRINT,PUNCH) = ALL

MPCFØRCE = NØNE

Option:

SØRT1	Output will be presented as a tabular listing of grid points for each subcase or frequency, depending on the rigid format. SORT2 is not available.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Multipoint forces of constraint for all points will be output (only nonzero entries).
NØNE	Multipoint forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only multipoint constraint forces for points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. MPCFØRCE = NØNE allows overrriding an overall output request.
3. Only valid for statics and real eigenvalue analyses. Module EQMCK and ØFP must be altered into the rigid format. See Section 5.10 for instructions.
4. A request for MPCFØRCE is not allowed for axisymmetric elements.

Case Control Data Card NCHECK - Stress and Element Forces Numerical Accuracy Check

Description: Requests stress and element force numerical accuracy check.

Format and Example(s):

NCHECK [= n]

NCHECK

NCHECK = 6

Option	Meaning
n	A printout of the number of significant digits accuracy is issued for each element element having an entry with less than n significant digits in the stress or force calculation.

Remarks:

1. All the elements requested on the STRESS and/or FØRCE card (or their equivalent ELSTRESS and/or ELFØRCE card) are checked.
2. The default for n if five (5) when n is not specified.
3. These checks measure the quality of the computations to obtain element stresses and element forces. They do not measure the quality of the model being analyzed.
4. See Theoretical Manual Section 3.7.4 for a description of the accuracy check.
5. The printout identifies the element types, identification number and the subcase. The entries checked are as follows.

Element Type	Entries
RØD,CØNRØD,TUBE	$F_A, T, \sigma_A, \sigma_T$
BAR	$F_A, T, M_{1a}, M_{1b}, M_{2a}, M_{2b}, V_1, V_2, \sigma_a$
TRMEM,QDMEM,QDMEM1	$\sigma_x, \sigma_y, \tau_{xy}$
TRPLT,QDPLT,TRIA1,TRIA2,QUAD1,QUAD2,TRBSC	$\sigma_{x1}, \sigma_{y1}, \sigma_{xy1}, \sigma_{x2}, \sigma_{y2}, \tau_{xy2}, M_x, M_y, M_{xy}, V_x, V_y$
HEXA1,HEXA2,WEDGE,TETRA	$\sigma_x, \sigma_y, \sigma_z, \tau_{yz}, \tau_{xz}, \tau_{xy}$
SHEAR	$\sigma_{MAX}, \sigma_{AVE}$, corner forces, kick forces, and shears.
TWIST	$\sigma_{MAX}, \sigma_{AVE}, M_{1-3}, M_{2-4}$
QDMEM2	$\sigma_x, \sigma_y, \tau_{xy}$, corner forces, kick forces, and shears.
IHEX1, IHEX2, IHEX3	σ_{NORMAL}, σ_{SHEAR}, and $\sigma_{PRINCIPAL}$ for each direction, grid point, and centroid.

Case Control Data Card NLLØAD - Nonlinear Load Output Request.

Description: Requests form and type of nonlinear load output for Transient problems.

Format and Example(s):

$$\text{NLLØAD } \left[\left(\frac{\text{PRINT}}{\text{PUNCH}} \right) \right] = \begin{Bmatrix} \text{ALL} \\ n \\ \text{NØNE} \end{Bmatrix}$$

NLLØAD = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Nonlinear loads for all solution points will be output.
NØNE	Nonlinear loads will not be output.
n	Set identification of previously appearing SET card. (Integer > 0). Only nonlinear loads for points whose identification numbers appear on this SET card will be output.

Remarks:
1. Both PRINT and PUNCH may be used.
2. Nonlinear loads are output only in the solution (D or H) set.
3. The output format will be SØRT2.
4. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
5. THERMAL = NØNE allows overriding an overall output request.

Case Control Data Card NØNLINEAR - Nonlinear Load Set Selection.

Description: Selects nonlinear load for transient problems.

Format and Example(s):

NØNLINEAR = n

NØNLINEAR LØAD SET = 75

Option	Meaning
n	Set identification of NØLINi cards (Integer > 0).

Remarks: NØLINi cards will not be used unless selected in Case Control.

Case Control Data Card ØFREQUENCY - Output Frequency Set.

Description: Selects from the solution set of frequencies a subset for output requests in direct or modal frequency analysis. In flutter analysis, it selects a subset of velocities.

Format and Example(s):

$$\text{ØFREQUENCY} = \left\{ \begin{matrix} \underline{\text{ALL}} \\ \text{n} \end{matrix} \right\}$$

ØFREQUENCY = ALL

ØFREQUENCY SET = 15

Option	Meaning
ALL	Output for all frequencies will be printed out.
n	Set identification of previously appearing SET card. (Integer > 0). Output for frequencies closest to those given on this SET card will be output.

Remarks:

1. ØFREQUENCY is defaulted to ALL if it is not supplied.
2. In fultter analysis, the selected set lists velocities in input units. If there are n velocities in the list, the n points with velocities closest to those in the list will be selected for output.
3. This card is used in conjunction with the MØDACC module to limit the frequencies for which mode acceleration computations are performed.
4. In Flutter Analysis, the selected set refers to the imaginary part of the complex eigenvalues.

   K or KE method: Velocity (input units)
   PK method: Frequency

5. In Aeroelastic Response (with RLØAD selection), the selected set refers to the frequency (cycles per unit time).

Case Control Data Card ØLØAD - Applied Load Output Request

Description: Requests form and type of applied load vector output.

Format and Example(s):

$$\text{ØLØAD} \left[\left(\begin{matrix} \text{SØRT1} \\ \text{SØRT2} \end{matrix}, \begin{matrix} \text{PRINT} \\ \text{PUNCH} \end{matrix}, \begin{matrix} \text{REAL} \\ \text{IMAG} \\ \text{PHASE} \end{matrix} \right) \right] = \left\{ \begin{matrix} \text{ALL} \\ n \\ \text{NØNE} \end{matrix} \right\}$$

ØLØAD = ALL

ØLØAD(SØRT1, PHASE) = 5

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase (0.0° ≤ phase < 360.0°) on Complex Eigenvalue or Frequency Response problems.
ALL	Applied loads for all points will be output. (SØRT1 will only output nonzero values).
NØNE	Applied loads for no points will be output.
n	Set identification of previously appearing SET card. Only loads on points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. A request for SØRT2 causes loads (zero and nonzero) to be output.
5. ØLØAD = NØNE allows overriding an overall output request.

Case Control Data Card **ØTIME** - Output Time Set

Description: Selects from the solution set of times a subset for output requests.

Format and Example(s):

$$ØTIME = \left\{ \frac{ALL}{n} \right\}$$

ØTIME = ALL

ØTIME = 15

Option	Meaning
ALL	Output for all times will be printed out.
n	Set identification of previously appearing SET card. (Integer > 0). Output for times closest to those given on this SET card will be output.

Remarks:
1. ØTIME is defaulted to ALL if it is not supplied.
2. The ØTIME card is particularly useful for restarts to request a subset of the output (i.e., stresses at only peak times, etc.).
3. This card can be used in conjunction with the MØDACC module to limit the times for which mode acceleration computations are performed.

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Case Control Data Card ØUTPUT - Output Packet Delimiter.

Description: Delimits the various output packets, structure plotter, curve plotter, and printer/punch.

Format and Example(s):

ØUTPUT $\left[\begin{pmatrix} \text{PLØT} \\ \text{XYØUT} \\ \text{XYPLØT} \end{pmatrix}\right]$

ØUTPUT

ØUTPUT(PLØT)

ØUTPUT(XYØUT)

Option	Meaning
No qualifier	Beginning of printer output packet - this is not a required card.
PLØT	Beginning of structure plotter packet. This card must preceed all structure plotter control cards.
XYØUT or XYPLØT	Beginning of curve plotter packet. This card must precede all curve plotter control cards. XYPLØT and XYØUT are entirely equivalent.

Remarks:

1. The structure plotter packet and the curve plotter packet must be at the end of the Case Control Deck. Either may come first.

2. The delimiting of a printer packet is completely optional.

Case Control Data Card PLCØEFFICIENT - Piecewise Linear Coefficient Set.

Description: Selects the coefficient set for Piecewise Linear problems.

Format and Example(s):

$$\text{PLCØEFFICIENT} = \begin{Bmatrix} \text{DEFAULT} \\ n \end{Bmatrix}$$

PLCØEFFICIENT = DEFAULT

PLCØEFFICIENT = 25

Option	Meaning
DEFAULT	A single default coefficient of value 1.0.
n	Set identification of PLFACT card (Integer > 0).

Remarks: PLFACT cards will not be used unless selected.

Case Control Data Card PLØTID - Plotter Identification.

Description: Defines BCD identification which will appear on the first frame of any NASTRAN plotter output.

Format and Example(s):

PLØTID = { Any BCD data }

PLØTID = RETURN TØ B.J. SMITH, RØØM 201, BLDG 85, ABC CØMPANY

Remarks: 1. PLØTID must appear before the ØUTPUT(PLØT) or ØUTPUT(XYØUT) cards.

2. The presence of PLØTID causes a special header frame to be plotted with the supplied identification plotted several times. This allows easy identification of NASTRAN plotter output.

3. If no PLØTID card appears, no ID frame will be plotted.

4. The PLØTID header frame will not be generated for the table plotters.

Case Control Data Card PRESSURE - Hydroelastic Pressure Output Request.

Description: Requests form and type of displacement and hydroelastic pressure vector output.

Format and Example(s):

$$\text{PRESSURE}\left[\left(\begin{array}{l}\underline{\text{SØRT1}}\\ \text{SØRT2}\end{array}, \begin{array}{l}\underline{\text{PRINT}}\\ \text{PUNCH}\end{array}, \begin{array}{l}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ n\\ \text{NØNE}\end{array}\right\}$$

PRESSURE = 5

PRESSURE(IMAG) = ALL

PRESSURE(SØRT2, PUNCH, REAL) = ALL

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point. SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements and pressures for all points will be output.
NØNE	Displacements and pressures for no points will be output.
n	Set identification of previously appearing SET card. Only displacements and pressures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. DISPLACEMENT and VECTØR are alternate forms and are entirely equivelent to PRESSURE.
5. PRESSURE = NØNE allows overriding an overall output request.

Case Control Data Card SDISPLACEMENT - Solution Set Displacement Output Request.

Description: Requests form and type of solution set displacement output.

Format and Example(s):

$$\text{SDISPLACEMENT}\left[\left(\frac{\text{SØRT1}}{\text{SØRT2}},\ \frac{\text{PRINT}}{\text{PUNCH}},\ \begin{array}{c}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{array}\right)\right] = \left\{\begin{array}{c}\text{ALL}\\ n\\ \text{NØNE}\end{array}\right\}$$

SDISPLACEMENT = ALL

SDISPLACEMENT(SØRT2, PUNCH, PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of frequency or time for each grid point (or mode number). SØRT2 is available only in Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Displacements for all points (modes) will be output.
NØNE	Displacements for no points (modes) will be output.
n	Set identification of previously appearing SET card. Only displacements of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:
1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In a Frequency Response problem any request for SØRT2 causes all output to be SØRT2.
4. SVECTØR is an alternate form which is entirely equivalent to SDISPLACEMENT.
5. SDISPLACEMENT = NØNE allows overriding an overall output request.

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Case Control Data Card <u>SET</u> - Set Definition Card.

<u>Description</u>: 1) Lists identification numbers (point or element) for output requests.
2) Lists the frequencies for which output will be printed in Frequency Response Problems.

<u>Format and Example(s)</u>:

1) SET n = $\{i_1[,i_2, i_3$ THRU i_4 EXCEPT i_5, i_6, i_7, i_8 THRU $i_9]\}$

SET 77 = 5

SET 88 = 5, 6, 7, 8, 9, 10 THRU 55 EXCEPT 15, 16, 77,
78, 79, 100 THRU 300

SET 99 = 1 THRU 100000

2) SET n = $\{r_1 [, r_2, r_3, r_4]\}$

SET 101 = 1.0, 2.0, 3.0

SET 105 = 1.009, 10.2, 13.4,
14.0, 15.0

Option	Meaning
n	Set identification (Integer > 0). Any set may be redefined by reassigning its identification number. Sets inside SUBCASE delimiters are local to the SUBCASE.
i_1, i_2 etc.	Element or point identification number at which output is requested. (Integer > 0) If no such identification number exists, the request is ignored.
i_3 THRU i_4	Output at set identification numbers i_3 thru i_4 ($i_4 > i_3$).
EXCEPT	Set identification numbers following EXCEPT will be deleted from output list as long as they are in the range of the set defined by the immediately preceding THRU.
r_1, r_2 etc.	Frequencies for output (Real $\geq$ 0.0). The nearest solution frequency will be output. EXCEPT and THRU cannot be used.

<u>Remarks</u>:

1. A SET card may be more than one physical card. A comma (,) at the end of a physical card signifies a continuation card. Commas may not end a set.

2. Set identification numbers following EXCEPT within the range of the THRU must be in ascending order.

3. In the first format, i_8 must be greater than i_4, i.e., the THRU must not be within an EXCEPT range.

Case Control Data Card SPC - Single-Point Constraint Set Selection.

Description: Selects the single-point constraint set to be applied to the structural model.

Format and Example(s):

SPC = n

SPC = 10

Option	Meaning
n	Set identification of a single-point constraint set and hence must appear on an SPC, SPC1, SPCADD, SPCAX, SPCS, or SPCS1 card (Integer > 0).

Remarks: SPC, SPC1, SPCADD, SPCAX, SPCS, or SPCS1 cards will not be used by NASTRAN unless selected in Case Control.

Case Control Data Card SPCFØRCES - Single-Point Forces of Constraint Output Request.

Description: Requests form and type of Single-Point Force of constraint vector output.

Format and Example(s):

$$\text{SPCFØRCES} \quad \left[\left(\begin{matrix}\underline{\text{SØRT1}}\\ \text{SØRT2}\end{matrix}, \begin{matrix}\underline{\text{PRINT}}\\ \text{PUNCH}\end{matrix}, \begin{matrix}\underline{\text{REAL}}\\ \text{IMAG}\\ \text{PHASE}\end{matrix}\right)\right] = \left\{\begin{matrix}\text{ALL}\\ n\\ \text{NØNE}\end{matrix}\right\}$$

SPCFØRCES = 5

SPCFØRCES(SØRT2, PUNCH, PRINT, IMAG) = ALL

SPCFØRCES(PHASE) = NØNE

Option	Meaning
SØRT1	Output will be presented as a tabular listing of grid points for each load, frequency, eigenvalue, or time, depending on the rigid format. SØRT1 is not available in Transient problems (where the default is SØRT2).
SØRT2	Output will be presented as a tabular listing of load, frequency, or time for each grid point. SØRT2 is available only in Static Analysis, Transient and Frequency Response problems.
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
REAL or IMAG	Requests real and imaginary output on Complex Eigenvalue or Frequency Response problems.
PHASE	Requests magnitude and phase ($0.0° \leq$ phase $< 360.0°$) on Complex Eigenvalue or Frequency Response problems.
ALL	Single-Point forces of constraint for all points will be output. (SØRT1 will only output nonzero values.)
NØNE	Single point forces of constraint for no points will be output.
n	Set identification of previously appearing SET card. Only single-point forces of constraint for points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested.
2. An output request for ALL in Transient and Frequency response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.
3. In Static Analysis or Frequency Response problems, any request for SØRT2 output causes all output to be SØRT2.
4. A request for SØRT2 causes loads (zero and nonzero) to be output.
5. SPCFØRCES = NØNE allows overriding an overall output request.
6. In heat transfer analysis, SPCFØRCE output is the power necessary to maintain a grid point at a fixed temperature.

Case Control Data Card TEMPERATURE - Thermal Properties Set Selection.

Description: Selects the temperature set to be used in either material property calculation or thermal loading.

Format and Example(s):

$$\text{TEMPERATURE}\left[\begin{pmatrix}\text{MATERIAL}\\ \text{LØAD}\\ \underline{\text{BØTH}}\end{pmatrix}\right] = n$$

TEMPERATURE(LØAD) = 15

TEMPERATURE(MATERIAL) = 7

TEMPERATURE = 7

Option	Meaning
MATERIAL	The selected temperature table will be used to determine temperature-dependent material properties indicated on the MATTi type cards.
LØAD	The selected temperature table will be used to determine an equivalent static load.
BØTH	Both options, MATERIAL and LØAD will use the same temperature table.
n	Set identification number of TEMP, TEMPD, TEMPP1, TEMPP2, TEMPP3, TEMPRB, or TEMPAX cards (Integer > 0).

Remarks:

1. Only one temperature-dependent material request may be made in any problem and must be above the subcase level.

2. Thermal loading may only be used in Statics, Inertia Relief, Differential Stiffness, and Buckling problems.

3. Temperature-dependent materials may not be used in Piecewise Linear problems.

4. The total load applied will be the sum of external (LØAD), thermal (TEMP(LØAD)), element deformation (DEFØRM) and constrained displacement (SPC) loads.

5. Static, thermal and element deformation loads should have unique set identification numbers.

6. In heat transfer analysis, the TEMP data is used for the following special purposes:

   a) The Case Control card TEMP(MATERIAL) will select the initial estimated temperature field for nonlinear conductivity and radiation effects. See Section 1.8 (APP HEAT, Rigid Formats 1, 3, and 9).

   b) In Rigid Format 3, heat boundary temperatures are defined by the specified Case Control card TEMP(MATERIAL). These points are specified with SPC data.

Case Control Data Card TFL - Transfer Function Set Selection.

Description: Selects the Transfer function set to be added to the direct input matrices.

Format and Example(s):

TFL = n

TFL = 77

Option	Meaning
n	Set identification of a TF card (Integer > 0).

Remarks:
1. Transfer functions will not be used unless selected in the Case Control Deck.
2. Transfer functions are supported on dynamics problems only.
3. Transfer functions are simply another form of direct matrix input.

Case Control Data Card THERMAL - Temperature Output Request.

Description: Requests form and type of temperature vector output.

Format and Example(s):

$$\text{THERMAL} \left[\begin{matrix}\text{PRINT} \\ \text{PUNCH}\end{matrix} , \begin{matrix}\text{SØRT1} \\ \text{SØRT2}\end{matrix}\right] = \left\{\begin{matrix}\text{ALL} \\ n \\ \text{NØNE}\end{matrix}\right\}$$

THERMAL = 5

THER(PRINT,PUNCH) = ALL

Option	Meaning
PRINT	The printer will be the output media.
PUNCH	The card punch will be the output media.
ALL	Temperatures for all points will be output.
NØNE	Temperatures for no points will be output.
n	Set identification of previously appearing SET card. Only temperatures of points whose identification numbers appear on this SET card will be output (Integer > 0).

Remarks:

1. Both PRINT and PUNCH may be requested. The punched output will consist of double field TEMP* Bulk Data cards defining the temperatures at the grid points.

2. THERMAL output request is designed for use with the Heat Transfer option. The printed output will have temperature headings and the punched output will be TEMP bulk data cards. The SID on a bulk data card will be the subcase number (= 1 if no defined subcases). The output format will be SØRT1 for Static problems and SØRT2 for Transient problems.

3. An output request for ALL in Transient response problems generally produces large amounts of printout. An alternative to this would be to define a SET of interest.

4. DISPLACEMENT and VECTØR are alternate forms and are entirely equivalent to THERMAL.

5. THERMAL = NØNE allows overriding an overall output request.

6. The output format will be SØRT1 for Rigid Formats 1 and 3; SØRT2 for Rigid Format 9.

7. If punched output is desired in Rigid Format 9 for subsequent use in the other Rigid Formats, SØRT1 format must be selected.

Input Data Card **AEFACT** Aerodynamic Spanwise Divisions

Description: Used to specify box division points for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AEFACT	SID	D1	D2	D3	D4	D5	D6	D7	ABC
AEFACT	97	.3	.7	1.0					

+BC	D8	D9	--etc.-						

Field	Contents
SID	Set identification number (Unique Integer > 0).
Di	Division point (Real).

Remarks:

1. These factors must be selected by a CAERØ1 or PAERØ1 data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. If used to specify box division points, note that there is one more division point than the number of boxes.

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Input Data Card **AERØ** Aerodynamic Physical Data

Description: Gives basic aerodynamic parameters.

Format and Examples:

1	2	3	4	5	6	7	8	9	10
AERØ	ACSID	VELØCITY	REFC	RHØREF	SYMXZ	SYMXY			
AERØ	3	1.3+4	100.	1.-5		1			

Field	Contents
ACSID	Aerodynamic coordinate system identification (Integer ≥ 0). See Remark 2.
VELØCITY	Velocity (Real).
REFC	Reference length (for reduced frequency) (Real).
RHØREF	Reference density (Real).
SYMXZ	Symmetry key for aero coordinate x-z plane (Integer) (+1 for sym, =0 for no sym, -1 for anti-sym).
SYMXY	Symmetry key for aero coordinate x-y plane can be used to simulate ground effects (Integer), same code as SYMXZ.

Remarks:

1. This card is required for aerodynamic response problems. Only one AERØ card is allowed.
2. The ACSID must be a rectangular coordinate system. Flow is in the positive x direction.

Input Data Card **ASET** Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET	ID	C	ID	C	ID	C	ID	C	
ASET	16	2	23	3516			1	4	

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number, zero or blank for scalar points, any unique combination of the digits 1-6 for grid points

Remarks:

1. Coordinates specified on ASET cards may not be specified on ØMIT, ØMIT1, ASET1, SPC or SPC1 cards nor may they appear as dependent coordinates in multipoint constraint relations (MPC) or as rigid elements (CRIGD1, CRIGD2, CRIGD3, CRIGDR) or as permanent single-point constraints on a GRID card.
2. As many as 24 coordinates may be placed in the analysis set by a single card.
3. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained or referenced on a SUPØRT card, will be placed in the Ø-set.
4. ASET of ØMIT data are not recommended for use in heat transfer analysis with radiation effects.

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Input Data Card ASET1 Selected Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to place in the analysis set. Used to define the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ASET1	C	G	G	G	G	G	G	G	abc
ASET1	345	2	1	3	10	9	6	5	ABC

+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ASET1	C	ID1	"THRU"	ID2					
ASET1	123456	7	THRU	109					

Field	Contents
C	Component number (any unique combination of the digits 1-6 [with no imbedded blanks] when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points).
G,ID1,ID2	Grid or scalar point identification numbers (Integer > 0, ID1 < ID2)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation (MPC card) or as a degree of freedom on a rigid element (CRIGD1, CRIGD2, CRIGD3, CRIGDR), nor may it be referenced on an SPC, SPC1, ØMIT, ØMIT1, or ASET card or on a GRID card as permanent single-point constraints.
2. When ASET and/or ASET1 cards are present, all degrees of freedom not otherwise constrained or referenced on a SUPØRT card will be placed in the Ø-set.
3. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.
4. ASET or ØMIT data are not recommended for use in heat transfer analysis with radiation effects.

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C-3

Input Data Card AXIC Axisymmetric Problem "Flag"

Description: Defines the existence of a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
AXIC	H								
AXIC	15								

Field	Contents
H	Highest harmonic defined for the problem ($0 \leq$ Integer ≤ 998)

Remarks: 1. Only one (1) AXIC card is allowed. When the AXIC card is present, most other cards are not allowed. The types which are allowed with the AXIC card are listed below.

CCØNEAX	GRAV	RLØAD1
CTRAPAX	LØAD	RLØAD2
CTRIAAX	MAT1	SECTAX
DAREA	MATT1	SPCADD
DELAY	MØMAX	SPCAX
DLØAD	MØMENT	SUPAX
DMI	MPCADD	TABDMP1
DMIG	MPCAX	TABLED1
DPHASE	NØLIN1	TABLED2
DSFACT	NØLIN2	TABLED3
EIGB	NØLIN3	TABLED4
EIGC	NØLIN4	TABLEM1
EIGP	ØMITAX	TABLEM2
EIGR	PARAM	TABLEM3
EPØINT	PCØNEAX	TABLEM4
FØRCE	PØINTAX	TEMPAX
FØRCEAX	PRESAX	TF
FREQ	PTRAPAX	TIC
FREQ1	PTRIAAX	TLØAD1
FREQ2	RFØRCE	TLØAD2
	RINGAX	TSTEP

2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

3. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card BARØR Simple Beam Orientation Default

Description: Defines default values for fields 3 and 6-9 of the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
BARØR		PID			X1,GO	X2	X3	F	
BARØR		39			0.6	2.9	-5.87	1	

Field	Contents
PID	Identification number of PBAR property card (Integer > 0 or blank)
X1, X2, X3	Vector components measured in displacement coordinate system at GA to determine (with the vector from end A to end B) the orientation of the element coordinate system for the bar element (Real or blank; see below)
GO	Grid point identification number (Integer > 0; see below)
F	Flag to specify the nature of fields 6-8 as follows:

	6	7	8
F = 1	X1	X2	X3
F = 2	GO	blank	blank

Remarks:
1. The contents of fields on this card will be assumed for any CBAR card whose corresponding fields are blank.
2. Only one BARØR card may appear in the user's Bulk Data Deck.
3. For an explanation of bar element geometry, see Section 1.3.2.
4. If F=2, GO must be given even though it may be overriden on every CBAR card.

Input Data Card **CAERØ1** Aerodynamic Panel Element Connection

Description: Defines an aerodynamic macro element (panel) in terms of two leading edge locations and side chords for Doublet-Latice Theory.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CAERØ1	EID	PID	CP	NSPAN	NCHØRD	LSPAN	LCHØRD	IGID	ABC
CAERØ1	1000	1		3			2	1	ABC
+BC	X1	Y1	Z1	X12	X4	Y4	Z4	X43	
+BC	0.0	0.0	0.0	1.0	0.2	1.0	0.0	0.8	

Field	Contents
EID	Element identification number (unique Integer > 0).
PID	Identification number of property card (Integer > 0) to specify associated bodies.
CP	Coordinate system for locating points 1 and 4 (Integer $\geq$ 0).
NSPAN	Number of spanwise boxes; if a positive value is given, equal divisions are assumed; if zero or blank, a list of division points follows (Integer $\geq$ 0).
NCHØRD	Nubmer of chordwise boxes (same rule as for NSPAN).
LSPAN	ID of an AEFACT data card containing a list of division points for spanwise boxes. Used only if field 5 is zero or blank (Integer > 0 if NSPAN is zero or blank).
LCHØRD	ID of an AEFACT data card containing a list of division points for chordwise boxes. Used only if field 6 is zero or blank (Integer > 0 if NCHØRD is zero or blank).
IGID	Interference group identification (aerodynamic elements with different IGID's are uncoupled) (Integer > 0).
X1,Y1,Z1;X4,Y4,Z4	Location of points 1 and 4, in coordinate system CP (Real).
X12; X43	Edge chord length (in aerodynamic coordinate system) (Real $\geq$ 0, and not both zero).

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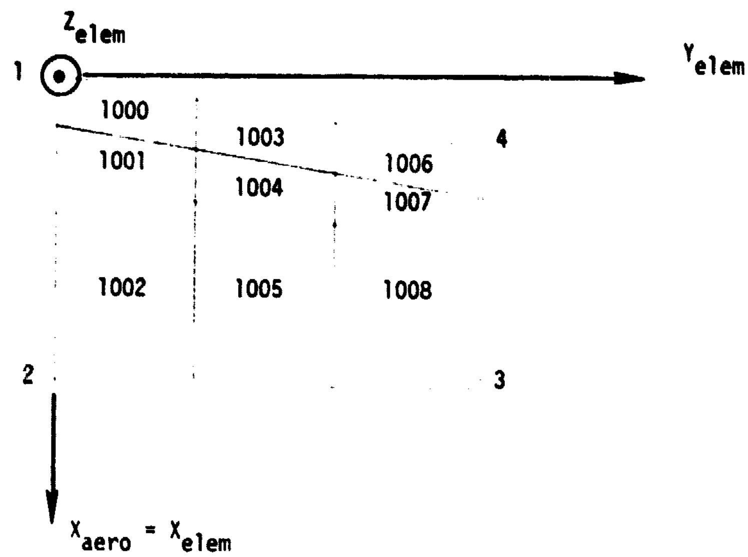
Remarks:



1. The boxes are numbered sequentially, beginning with EID. The user should be careful to ensure that all box numbers are unique, and different from structural grid ID's.

2. The number of division points is one greater than the number of boxes. Thus, if NSPAN = 3, the division points are 0.0, 0.333, 0.667, 1.000. If the user supplies division points, the first and last points need not be 0. and 1. (in which the corners of the panel would not be at the reference points).

3. A triangular element is formed if X12 <u>or</u> X43 = 0.

4. The element coordinate system (right-handed) is shown in the sketch.

5. The continuation card is required.

Input Data Card CCØNEAX Axisymmetric Shell Element Connection

Description: Defines the connection of a conical shell element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CCØNEAX	ID	PID	RA	RB					
CCØNEAX	1	2	3	4					

Field	Contents
EID	Unique element identification number ($1 \leq$ Integer ≤ 9999)
PID	Identification number of a PCØNEAX card (Default is EID) (Integer > 0)
RA	Identification number of a RINGAX card (Integer > 0; RA $\neq$ RB)
RB	Identification number of a RINGAX card (Integer > 0; RA $\neq$ RB)

Remarks:

1. This card is allowed if and only if an AXIC card is also present.
2. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

Input Data Card CDAMP1 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP1	EID	PID	G1	C1	G2	C2			
CDAMP1	19	6	0		23	2			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP3 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. The two connection points, (G1, C1) and (G2, C2), must be distinct.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
5. In heat transfer analysis, the CDAMP1 card may be used to define a lumped thermal capacitance ($Q=B\dot{T}$) if connected to grid point S1.

*A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP2 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP2	EID	B	G1	C1	G2	C2			
CDAMP2	16	-2.98	32	1					

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The value of the scalar damper (Real)
G1, G2	Geometric grid point identification number (Integer $\geq$ 0)
C1, C2	Component number (6 $\geq$ Integer $\geq$ 0)

Remarks:
1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CDAMP4 card.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This single card completely defines the element since no material or geometric properties are required.
4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
6. In heat transfer analysis the CDAMP2 card may be used to define a lumped thermal capacitance ($Q=B\dot{T}$) if connected to grid point S1.

*A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

Input Data Card CDAMP3 Scalar Damper Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP3	EID	PID	S1	S2	EID	PID	S1	S2	
CDAMP3	16	978	24	36	17	978	24	37	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PDAMP property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar damper elements may be defired on a sinole card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
5. In heat transfer analysis the CDAMP3 card may be used to define a lumped thermal capacitance ($Q=B\dot{T}$) if connected to grid point S1.

Input Data Card CDAMP4 Scalar Damper Property and Connection

Description: Defines a scalar damper element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CDAMP4	EID	B	S1	S2	EID	B	S1	S2	
CDAMP4	16	-2.6	4	9	17	+8.6	3	7	

Field	Contents
EID	Unique element identification number (Integer > 0)
B	The scalar damper value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. One or two scalar damper elements may be defined on a single card.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
6. In heat transfer analysis the CDAMP4 card may be used to define a lumped thermal capacitance ($Q=B\dot{T}$) if connected to grid point S1.

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Input Data Card CELAS1 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS1	EID	PID	G1	C1	G2	C2			
CELAS1	2	6			8	1			

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
G1, G2	Geometric grid point identification number (Integer > 0)
C1, C2	Component number ($6 \geq$ Integer ≥ 0)

Remarks:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank or zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS3 card.

2. Element identification numbers must be unique with respect to all other element identification numbers.

3. The two connection points, (G1, C1) and (G2, C2), must be distinct.

4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.

5. In heat transfer analysis the CELAS1 card may be used to define a conduction or convection between two points or to ground ($Q = K\Delta T$).

*A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

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Input Data Card <u>CELAS2</u> Scalar Spring Property and Connection

<u>Description</u>: Defines a scalar spring element of the structural model without reference to a property value.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
CELAS2	EID	K	G1	C1	G2	C2	GE	S	
CELAS2	28	6.2+3	32		19	4			

<u>Field</u>	<u>Contents</u>
EID	Unique element identification number ($0 < \text{Integer} \leq 10^7$ if acoustic)
K	The value of the scalar spring (Real)
G1, G2	Geometric grid point identification number (Integer ≥ 0)
C1, C2	Components number ($6 \geq \text{Integer} \geq 0$)
GE	Damping coefficient (Real)
S	Stress coefficient (Real)

<u>Remarks</u>:

1. Scalar points may be used for G1 and/or G2 in which case the corresponding C1 and/or C2 must be zero or blank. Zero or blank may be used to indicate a grounded* terminal G1 or G2 with a corresponding blank of zero C1 or C2. If only scalar points and/or ground are involved, it is more efficient to use the CELAS4 card.
2. Element identification numbers must be unique with respect to <u>all</u> other element identification numbers.
3. This single card completely defines the element since no material or geometric properties are required.
4. The two connection points, (G1, C1) and (G2, C2), must be distinct.
5. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
6. In heat transfer analysis the CELAS2 card may be used to define a conduction or convection between two points or to ground ($Q=K\Delta T$).

*A grounded terminal is a scalar point or coordinate of a geometric grid point whose displacement is constrained to zero.

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Input Data Card CELAS3 Scalar Spring Connection

Description: Defines a scalar spring element of the structural model which is connected only to scalar points.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS3	EID	PID	S1	S2	EID	PID	S1	S2	
CELAS3	19	2	14	15	2	3	0	28	

Field	Contents
EID	Unique element identification number (Integer > 0)
PID	Identification number of a PELAS property card (Default is EID) (Integer > 0)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:

1. S1 or S2 may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. One or two scalar springs may be defined on a single card.
4. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
5. In heat transfer analysis the CELAS3 card may be used to define a conduction or convection between two points or to ground (Q=KΔT).

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Input Data Card CELAS4 Scalar Spring Property and Connection

Description: Defines a scalar element of the structural model which is connected only to scalar points without reference to a property value.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CELAS4	EID	K	S1	S2	EID	K	S1	S2	
CELAS4	42	6.2-3	2		13	6.2-3	0	2	

Field	Contents
EID	Unique element identification number (Integer > 0)
K	The scalar spring value (Real)
S1, S2	Scalar point identification numbers (Integer $\geq$ 0; S1 $\neq$ S2)

Remarks:
1. S1 or S2 but not both may be blank or zero indicating a constrained coordinate.
2. Element identification numbers must be unique with respect to all other element identification numbers.
3. This card completely defines the element since no material or geometric properties are required.
4. No damping coefficient is available with this form. (Assumed to be 0.0)
5. No stress coefficient is available with this form.
6. One or two scalar springs may be defined on a single card.
7. For a discussion of the scalar elements, see Section 5.6 of the Theoretical Manual.
8. In heat transfer analysis the CELAS4 card may be used to define a conduction or convection between two points or to ground ($Q=K\Delta T$).

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Input Data Card CHBDY Heat Boundary Element

Description: Defines a boundary element for heat transfer analysis which is used for heat flux, thermal vector flux, convection and/or radiation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CHBDY	EID	PID	TYPE	G1	G2	G3	G4		
CHBDY	721	100	LINE	101	98				+BD721
+abc	GA1	GA2	GA3	GA4	V1	V2	V3		
+BD721	102	102			1.00	0.0	0.0		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Property identification number (Integer > 0)
TYPE	Type of area involved (must be one of "PØINT", "LINE", "REV", "AREA3", "AREA4" or "ELCYL")
G1,G2,G3,G4	Grid point identification numbers of primary connected points (Integer > 0 or blank)
GA1,GA2,GA3,GA4	Grid or scalar point identification numbers of associated ambient points (Integer > 0 or blank)
V1,V2,V3	Vector (in the basic coordinate system) used for element orientation (real or blank)

Remarks:

1. The continuation card is not required.
2. The six types have the following characteristics:
   a. The "PØINT" type has one primary grid point, requires a property card, and the normal vector {V1,V2,V3} must be given if thermal vector flux is to be used.
   b. The "LINE" type has two primary grid points, requires a property card, and the vector is required if thermal vector flux is to be used.
   c. The "REV" type has two primary grid points which must lie in the x-z plane of the basic coordinate system with x > 0. The defined area is a conical section with z as the axis of symmetry. A property card is required for convection, radiation, or thermal vector flux.
   d. The "AREA3" and "AREA4" types have three and four primary grid points, respectively. These points define a triangular or quadrilateral surface and must be ordered to go around the boundary. A property card is required for convection, radiation, or thermal vector flux.
   e. The "ELCYL" type (elliptic cylinder) has two connected primary grid points, it requires a property card, and if thermal vector flux is used, the vector must be nonzero.

CHBDY (Cont.)

3. A property card, PHBDY, is used to define the associated area factors, the emissivity, the absorbtivity, and the principal radii of the elliptic cylinder. The material coefficients used for convection and thermal capacity are referenced by the PHBDY card. See this card description for details.

4. The associated points, GA1, GA2, etc., may be either grid or scalar points, and are used to define the fluid ambient temperature when a convection field exists. These points correspond to the primary (CHBDY element) points G1, G2, etc., and the number of them depends on the TYPE option, but they need not be unique. Their values may be set in statics with an SPC card, or they may be connected to other elements. If any field is blank, the ambient temperature associated with that grid point is assumed to be zero.

5. Heat flux may be applied to this element with QBDY1 or QBDY2 cards.

6. Thermal vector flux from a directional source may be applied to this element with a QVECT card. The orientation of the normal vector must be defined. The grid point ordering establishes the normal vector direction as end "a" to end "b" for line elements and "right hand rule" for cross product elements. See Section 1.8 for the definition of the normal vector for each element type.

Input Data Card CØNCT1 Substructure Connectivity

Description: Defines the grid point and degree of freedom connectivities between two or more substructures for a manual CØMBINE operation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CØNCT1	SID	NAME1	NAME2	NAME3	NAME4	NAME5	NAME6	NAME7	def
CØNCT1	805	WINGRT	FUSELAGE	MIDWG	PØD				DEF
+ef	C1	G11	G12	G13	G14	G15	G16	G17	hij
+EF	123	528	17	32	106				HIJ
+ij	C2	G21	G22	G23	G24	G25	G26	G27	
+IJ	46	518							etc.

Field	Contents
SID	Identification number of connectivity set (Integer > 0)
NAMEi	Basic substructure name (BCD)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Gij	Grid or scalar point identification number in substructure namej with components Ci (Integer > 0)

Remarks:
1. As least one continuation card must be present.
2. Components specified on CØNCT1 card will not be overridden by RELES cards.
3. Several CØNCT and CØNCT1 cards may be input with the same value of SID.
4. An alternate format is given by the CØNCT card.
5. Connectivity sets must be selected in the Substructure Control Deck (CØNNECT=SID) to be used by NASTRAN. Note that 'CØNNECT' is a subcommand of the substructure CØMBINE command.
6. The NAMEi's must be the names of basic substructure components of the pseudostructures named on the CØMBINE card in the Substructure Control Deck. See the CØNCT card for a more complete discussion related to the combination of two substructures.

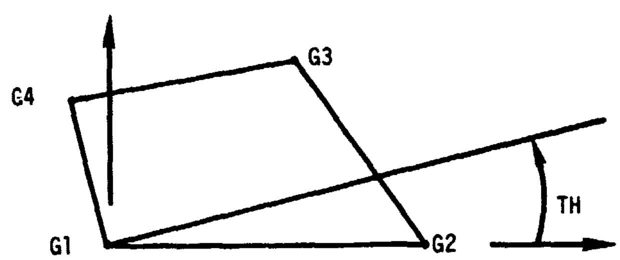
Input Data Card CQDMEM1 Isoparametric Quadrilateral Element Connection

Description: Defines an isoparametric quadrilateral membrane element (QDMEM1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM1	EID	PID	G1	G2	G3	G4	TH		
CQDMEM1	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM1 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0); G1 $\neq$ G2 $\neq$ G3 $\neq$ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180 degrees.

4. In a HEAT formulation, element type CQDMEM1 is automatically replaced by element type CQDMEM.

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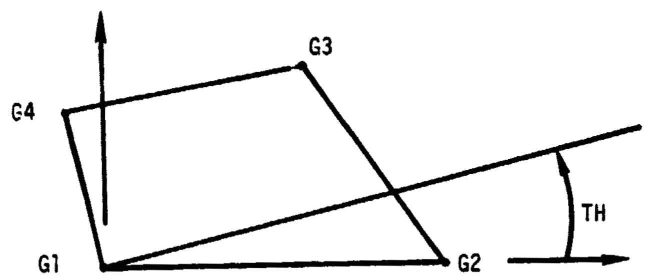
Input Data Card CQDMEM2 Quadrilateral Element Connection

Description: Defines a quadrilateral membrane element (QDMEM2) of the structural model consisting of four nonoverlapping TRMEM elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CQDMEM2	EID	PID	G1	G2	G3	G4	TH		
CQDMEM2	72	13	13	14	15	16	29.2		

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of a PQDMEM2 property card (Default is EID) (Integer > 0)
G1,G2,G3,G4	Grid point identification numbers of connection points (Integer > 0; G1 $\neq$ G2 $\neq$ G3 $\neq$ G4)
TH	Material property orientation angle in degrees (Real) The sketch below gives the sign convention for TH



Remarks: 1. Element identification numbers must be unique with respect to all other element identification numbers.

2. Grid points G1 through G4 must be ordered consecutively around the perimeter of the element.

3. All interior angles must be less than 180 degrees.

4. In a HEAT formulation, element type CQDMEM2 is automatically replaced by element type CQDMEM.

Input Data Card CRIGD1 Rigid Element Connection

Description: Defines a rigid element in which all six degrees of freedom of each of the dependent grid points are coupled to all six degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD1	EID	IG	G1	G2	G3	G4	G5	G6	abc
CRIGD1	101	15	18	43	9	26	35	41	123

+bc	G7	G8	G8	etc.					
+23	8	63							

Alternate Form:

CRIGD1	EID	IG	GID1	"THRU"	GID2				
CRIGD1	201	25	71	THRU	80				

Field	Contents
EID	Element identification number (Integer > 0)
IG	Identification number of the reference grid point (Integer > 0)
Gi, GIDi	Identification numbers of the dependent grid points (Integer > 0)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Only one reference grid point is allowed per element. It must appear before any of the dependent grid points.
3. Any number of dependent grid points may be specified.
4. When the alternate form is used, no continuation card is permitted and all grid points implied by GID1 thru GID2 (GID1 < GID2) must exist.
5. Dependent degrees of freedom defined (implicitly) for a RIDG1 element may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom for RIGD2, RIGD3, or RIGDR elements or on MPC cards.
6. Rigid elements are not allowed in heat transfer analysis.
7. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

Input Data Card CRIGD2 Rigid Element Connection

Description: Defines a rigid element in which selected degrees of freedom of the dependent grid points are coupled to all six degrees of freedom of the reference grid point.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGD2	EID	IG	G1	C1	G2	C2	G3	C3	abc
CRIGD2	102	20	9	12	45	123	53	135	123

+bc	G4	C4	etc.						
+23	27	456							

Field	Contents
EID	Element identification number (Integer > 0)
IG	Identification number of the reference grid point (Integer > 0)
Gi	Identification numbers of the dependent grid points (Integer > 0)
Ci	List of selected degrees of freedom associated with the preceding dependent grid point (any of the digits 1-6 with no imbedded blanks)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Only one reference grid point is allowed per element. It must appear before the dependent grid point data.
3. Any number of dependent grid points may be specified.
4. Dependent degrees of freedom defined in a CRIGD2 element may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom in CRIGD1, CRIGD3, or CRIGDR elements or on MPC cards.
5. Rigid elements are not allowed in heat transfer analysis.
6. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

Input Data Card CRIGD3 General Rigid Element Connection

Description: Defines a rigid element in which selected degrees of freedom of the dependent grid points are coupled to six selected degrees of freedom at one or more (up to six) reference grid points.

Format and Example

1	2	3	4	5	6	7	8	9	10
CRIGD3	EID	IG1	IC1	IG2	IC2	IG3	IC3		abc
CRIGD3	103	11	1	12	2	13	4		ABC
+bc		IG4	IC4	IG5	IC5	IG6	IC6		def
+BC		14	35	15	6				DEF
+ef	"MSET"	DG1	DC1	DG2	DC2	DG3	DC3		ghi
+EF	MSET	21	123	22	1	23	123456		GHI
+hi		DG4	DC4	DG5	DC5	etc.			
+HI		24	456	25	2				

Field	Contents
EID	Element identification number (Integer > 0)
IGi	Identification numbers of the reference grid points (Integer > 0)
ICi	List of selected degrees of freedom associated with the preceding reference grid point (any of the digits 1-6 with no imbedded blanks)
"MSET"	BCD string that indicates the start of the data for the dependent grid points
DGi	Identification numbers of the dependent grid points (Integer > 0)
DCi	List of selected degrees of freedom associated with the preceding dependent grid point (any of the digits 1-6 with no imbedded blanks)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.

2. The total number of degrees of freedom specified for the reference grid points (IC1 through IC6) must be six. Further, they should together be capable of representing any general rigid body motion of the element.

3. The first continuation card is not required if less than four reference grid points are specified.

4. The BCD word MSET is required in order to indicate the start of the dependent grid point data.

5. Any number of dependent grid points may be specified.

6. Dependent degrees of freedom defined in a CRIGD3 element may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom in CRIGD1, CRIGD2, or CRIGDR elements or on MPC cards.

CRIGD3 (Cont.)

7. Rigid elements are not allowed in heat transfer analysis.

8. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

BULK DATA DECK

Input Data Card CRIGDR Rigid Rod Element Connection

Description: Defines a pin-ended rod element that is rigid in extension-compression.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CRIGDR	EID	G	G1	C1	EID	G	G1	C1	
CRIGDR	104	5	9	3	302	12	4	2	

Field	Contents
EID	Element identification number (Integer > 0)
G	Identification number of the reference grid point (Integer > 0)
G1	Identification number of the dependent grid point (Integer > 0; G1 $\neq$ G)
C1	Dependent translational degree of freedom of grid point G1 ($1 \leq$ Integer ≤ 3)

Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Only one reference grid point and only one dependent grid point are allowed per element. The two points may not be coincident.
3. The direction represented by the dependent translational degree of freedom of the dependent grid point may not be perpendicular or nearly perpendicular to the element.
4. One or two RIGDR elements may be defined on a single card.
5. Dependent degrees of freedom defined for RIGDR elements may not appear on ØMIT, ØMIT1, SPC, SPC1 or SUPØRT cards nor may they be redundantly implied on ASET or ASET1 cards. They also may not appear as dependent degrees of freedom for RIGD1, RIGD2, or RIGD3 elements or on MPC cards.
6. Rigid elements are not allowed in heat transfer analysis.
7. For a discussion of rigid elements, see Section 3.5.6 of the Theoretical Manual.

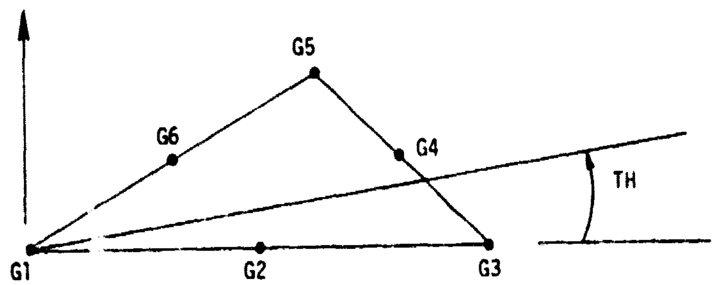
Input Data Card CTRIM6 Linear Strain Triangular Element Connection

Description: Defines a linear strain triangular membrane element (TRIM6) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRIM6	EID	PID	G1	G2	G3	G4	G5	G6	+abc
CTRIM6	220	666	100	110	120	210	220	320	AC3
+abc	TH								
+C3	90.0								

Field	Contents
EID	Element identification number (Integer > 0).
PID	Identification number of PTRIM6 property card (Default is EID) (Integer >0).
G1, G2, G3, G4, G5, G6	Grid point identification numbers of connection points (Integers > 0); G1 ≠ G2 ≠ G3 ≠ G4 ≠ G5 ≠ G6).
TH	Material property orientation angle in degrees (Real). The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Interior angles must be less than 180^{0}.
3. The gridpoints must be ordered consecutively around the perimeter in a counter clockwise direction and starting at a vertex.
4. Material properties (if MAT2 card is used) and stresses are given in the material coordinate system.
5. The continuation card must be present.
6. Grid points G2, G4, and G6 are assumed to lie at the midpoints of the sides. The locations of these points (defined by GRID cards) are used only for the global coordinate system definition, the Grid Point Weight Generator, centrifugal forces, and deformed structure plotting.

BULK DATA DECK

Input Data Card CTRPLT1 Triangular Element Connection

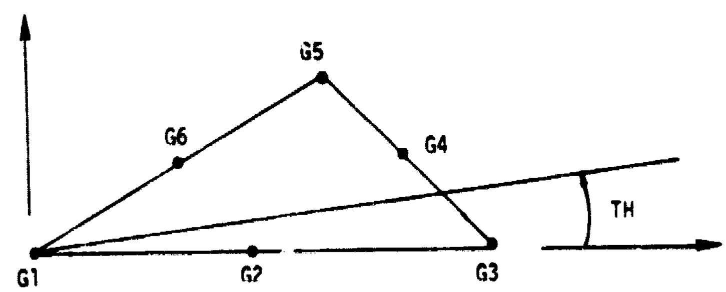
Description: Defines a higher order triangular bending element (TRPLT1) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRPLT1	EID	PID	G1	G2	G3	G4	G5	G6	abc
CTRPLT1	160	20	120	10	30	40	70	110	ABC

+bc	TH								
+BC	16.2								

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of PTRPLT1 property card (Default is EID) (Integer > 0)
G1, G2, G3, G4, G5, G6	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2 ≠ G3 ≠ G4 ≠ G5 ≠ G6)
TH	Material property orientation angle in degrees (Real)- The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Interior angles must be less than 180°.
3. The grid points must be ordered consecutively around the perimeter in counterclockwise direction and starting at a vertex.
4. The continuation card is required.

Input Data Card CTRSHL Triangular Shell Element Connection

Description: Defines a triangular thin shallow shell element (TRSHL) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CTRSHL	EID	PID	G1	G2	G3	G4	G5	G6	abc
CTRPLT	160	20	120	10	30	40	10	30	ABC

+bc	TH								
+BC	16.2								

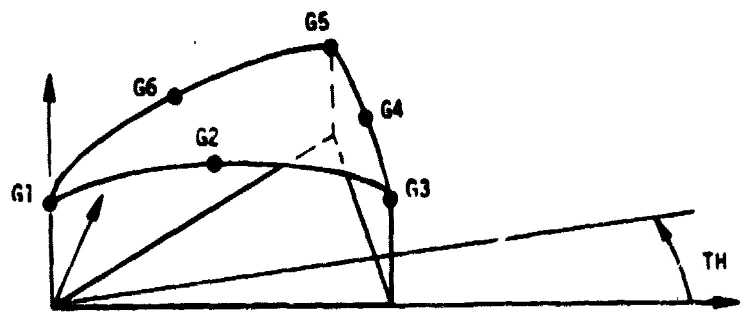
Field

EID Element identification number (Integer > 0)

PID Identification number of PTRSHL property card (Default is EID) (Integer > 0)

G1, G2, G3, G4, G5, G6 Grid point identification numbers of connection points (Integers > 0; G1 ≠ G2 ≠ G3 ≠ G4 ≠ G5 ≠ G6)

TH Material property orientation angle in degrees (Real) - The sketch below gives the sign convention for TH.



Remarks:

1. Element identification numbers must be unique with respect to all other element identification numbers.
2. Interior angles must be less than 180°.
3. The grid points must be listed consecutively around the perimeter in counter-clockwise direction starting at a vertex.
4. The continuation card must be present.

Input Data Card CVISC Viscous Damper Connection

Description: Defines a viscous damper element (VISC) of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
CVISC	EID	PID	G1	G2	EID	PID	G1	G2	
CVISC	21	6327	29	31	22	6527	35	33	

Field	Contents
EID	Element identification number (Integer > 0)
PID	Identification number of PVISC property card (Default is EID) (Integer > 0)
G1, G2	Grid point identification numbers of connection points (Integer > 0; G1 ≠ G2)

Remarks:
1. Element identification numbers must be unique with respect to all other element identification numbers.
2. One or two VISC elements may be defined on a single card.
3. Used only for direct formulation of dynamic analyses.

Input Data Card DMI Direct Matrix Input

Description: Used to define matrix data blocks directly. Generates a matrix of the form

$$[A] = \begin{bmatrix} A_{11} & A_{12} & \cdots\cdots & A_{1n} \\ A_{21} & A_{22} & \cdots\cdots & A_{2n} \\ \vdots & \vdots & & \vdots \\ A_{m1} & \cdots\cdots & \cdots\cdots & A_{mn} \end{bmatrix}$$

where the elements A_{ij} may be real or complex single-precision or double precision numbers.

Formats and Example: (The first logical card is a header card.)

1	2	3	4	5	6	7	8	9	10
DMI	NAME	"0"	FØRM	TIN	TØUT		M	N	
DMI	QQQ	0	2	3	3		4	2	

1	2	3	4	5	6	7	8	9	10
DMI	NAME	J	I1	A(I1,J)	A(I1+1,J)		etc.	I2	+abc
DMI	QQQ	1	1	1.0	2.0	3.0	4.0	3	+1
+abc	A(I2,J)		etc.						
+1	5.0	6.0							

1	2	3	4	5	6	7	8	9	10
DMI	QQQ	2	2	6.0	7.0	4	8.0	9.0	

(etc. for each nonnull column)

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphnumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
FØRM	1 Square matrix (not symmetric) 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 2 Real, double-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element) 4 Complex, double-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
M	Number of rows in A (Integer > 0)
N	Number of columns in A (Integer > 0)
J	Column number of A (Integer > 0)
I1,I2,etc.	Row number of A (Integer > 0)
A(Ix,J)	Element of A (See TIN) (Real)

(Continued)

Remarks: 1. The user must write a DMAP (or make alterations to a rigid format) in order to use the DMI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply. In the example shown above, the data block QQQ is defined to be the complex, single-precision rectangular 4x2 matrix

$$[QQQ] = \begin{bmatrix} (1.0,\ 2.0) & (0.0,\ 0.0) \\ (3.0,\ 4.0) & (6.0,\ 7.0) \\ (5.0,\ 6.0) & (0.0,\ 0.0) \\ (0.0,\ 0.0) & (8.0,\ 9.0) \end{bmatrix}$$

The DMAP data block NAME (QQQ in the example) will appear in the initial FIAT and the data block will initially appear on the Data Pool File (PØØL).

2. A limit to the number of DMI's which may be defined is set by the size of the Data Pool Dictionary. The total number of DMI's may not exceed this size.

3. There are a number of reserved words which may not be used for DMI names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, INP1 through INP9, GEØM1, GEØM2, GEØM3, GEØM4, GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH1 through SCRATCH9.

4. Field 3 of the header card must contain an integer 0.

5. For symmetric matrices, the entire matrix must be input.

6. Only nonzero terms need be entered.

7. A blank field on this card is not equivalent to a zero. If zero input is desired, the appropriate type zero must be punched (i.e., 0.0 or 0.0D0).

8. Complex input must have both the real and imaginary parts punched if either part is nonzero.

9. If A (IX,J) is followed by THRU in the next field and an integer row number IY after the THRU, then A (IX,J) will be repeated in each row through IY. The THRU must follow an element value. In the example below, 3.14 will be in rows 3 through 6 of column 1 and 2.0 in row 9.

DMI	QQQ	0	2	1	1		9	1	
DMI	QQQ	1	3	3.14	THRU	6	9	2.0	

Input Data Card DMIAX Direct Axisymmetric Matrix Input

Description: Defines axisymmetric (fluid or structure) related direct input matrix terms.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIAX	NAME	"0"	IFØ	TIN	TØUT				
DMIAX	B2PP	0	1	3	4				
DMIAX	NAME	GJ	CJ	NJ					+abc
DMIAX	B2PP	32							+BG27
+abc	GI	CI	NI	X_{ij}	Y_{ij}				+def
+BG27	1027	3		4.35+6	2.27+3				

-etc. for each column and row containing nonzero terms-

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix; 2 General rectangular matrix; 6 Symmetric matrix — Identification of Matrix Form
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double precision 4 Complex, double-precision
GJ, GI	Grid, scalar, RINGFL fluid point, PRESPT pressure point, FREEPT free surface displacement, or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ or GI grid point (0 ≤ Integer ≤ 6; Blank or zero if GJ or GI is a scalar, fluid, or extra point)
NJ, NI	Harmonic number of RINGFL point. Must be blank if a point type other than RINGFL is used. Negative number implies the "sine" series, positive implies the "cosine" series. (Integer)
X_{ij}, Y_{ij}	Real and Imaginary parts of matrix element; row (GI, CI, NI) column (GJ,CJ,NJ)

(Continued)

DMIAX (Cont.)

Remarks: 1. This card is allowed only if an AXIF card is also present.

2. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$ respectively.

3. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of two or more physical cards is needed for each nonnull column of the matrix.

4. If TIN = 1, Y_{ij} must be blank.

5. Field 3 of the header card must contain an interger 0.

6. For symmetric matrices, the entire matrix must be input.

7. Only nonzero terms need be entered.

8. There are a number of reserved words which may not be used for DMIAX names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, GEØM1, GEØM2, GEØM3, GEØM4, GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH1 thru SCRATCH9.

Input Data Card DMIG   Direct Matrix Input at Grid Points

Description: Defines structure-related direct input matrices.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DMIG	NAME	"0"	IFØ	TIN	TØUT				
DMIG	STIF	0	1	3	4				
DMIG	NAME	GJ	CJ		GI	CI	X_{ij}	Y_{ij}	Xabc
DMIG	STIF	27	1		2	3	3.+5	3.+3	EKG1
+abc	GI	CI	X_{ij}	Y_{ij}	GI	CI	X_{ij}	Y_{ij}	Xcef
+KG1	2	4	2.5+10	0.	50		1.0	0.	

etc. for each column containing nonzero terms

Field	Contents
NAME	BCD name of matrix (one to eight alphanumeric characters the first of which is alphabetic)
IFØ	1 Square matrix 2 General rectangular matrix 6 Symmetric matrix
TIN	Type of matrix being input as follows: 1 Real, single-precision (One field is used per element) 3 Complex, single-precision (Two fields are used per element)
TØUT	Type of matrix which will be created 1 Real, single-precision 3 Complex, single-precision 2 Real, double-precision 4 Complex, double-precision
GJ, GI	Grid or scalar or extra point identification number (Integer > 0)
CJ, CI	Component number for GJ a grid point ($0 < CJ \leq 6$); blank or zero for GJ a scalar or extra point
X_{ij}, Y_{ij}	Real and imaginary parts of matrix element

Remarks:

1. Matrices defined on this card may be used in dynamics by selection in the Case Control Deck by K2PP=NAME, B2PP=NAME, or M2PP=NAME for $[K^2_{pp}]$, $[B^2_{pp}]$, or $[M^2_{pp}]$, respectively.
2. In addition to the header card containing IFØ, TIN and TØUT, a logical card consisting of one or more physical cards is needed for each nonnull column of the matrix.
3. If TIN = 1, Y_{ij} must be blank.
4. Field 3 of the header card must contain an integer 0.
5. For symmetric matrices, the entire matrix must be input.
6. Only nonzero terms need be entered.
7. The matrix names must be unique among all DMIG's.

DMIG (Cont.)

8. There are a number of reserved words which may not be used for DMIG names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, GEØM1, GEØM2, GEØM3, GEØM4, GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, and DTI names, and SCRATCH1 thru SCRATCH9.

Input Data Card DSFACT Differential Stiffness Factor

Description: Used to define a scale factor for applied loads and stiffness matrix in a Normal Modes with Differential Stiffness Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
DSFACT	SID	B							
DSFACT	97	-1.0							

Field	Contents
SID	Set identification number (Unique Integer > 0)
B	Scale factor (Real)

Remarks: 1. Load sets must be selected in the Case Control Deck (DSCØ=SID) to be used by NASTRAN.

2. All fields following the entry must be blank.

Input Data Card DTI Direct Table Input

Description: Used to define table data blocks directly.

Format and Example: (The first logical card is a header card)

1	2	3	4	5	6	7	8	9	10
DTI	NAME	"0"	T1	T2	T3	T4	T5	T6	+00
DTI	XXX	0	3	4	4096	32768	1	0	
+00	V	V		-etc.-	ENDREC				+01
				-etc.-					
DTI	NAME	IREC	V	V	V	V	V	V	+11
DTI	XXX	1	2.0	-6	ABC	6.0D0	-1	2	+11
+11	V	V	V	V	-etc.-		ENDREC		+12
+11	4	-6.2	2.9	1	DEF	-1	ENDREC		

-etc.-

Field	Contents
NAME	Any NASTRAN BCD value (1-8 alphanumeric characters, the first of which must be alphabetic) which will be used in the DMAP sequence to reference the data block
Ti	Trailer values (65535 $\geq$ Integer $\geq$ 0)
IREC	Record Number (sequential integer beginning with 1)
V	Value (blank, integer, real, BCD (except "ENDREC"), double precision)
ENDREC	The BCD value ENDREC which flags the end of the string of values that constitute logical record IREC

Remarks:

1. Records may be made as long as desired via continuation cards.
2. Values may be of any type (blank, integer, real, BCD, double precision) with the exception that a BCD value may not be "ENDREC".
3. All fields following ENDREC must be blank.
4. The user must write a DMAP (or make alterations to a rigid format) in order to use the DTI feature since he is defining a data block. All of the rules governing the use of data blocks in DMAP sequences apply.
5. The DMAP data block NAME (XXX in the example) will appear in the initial FIAT and the data block will initially appear on the PØØL.
6. If trailer is not specified, T1 = number of records, T2 thru T6 = 0.
7. In addition to the header card, there must be one logical card for each record in the table.

DTI (Cont.)

8. There are a number of reserved words which may not be used for DTI names. Among these are PØØL, NPTP, ØPTP, UMF, NUMF, PLT1, PLT2, INPT, GEØM1, GEØM2, GEØM3, GEØM4, GEØM5, EDT, MPT, EPT, DIT, DYNAMICS, IFPFILE, AXIC, FØRCE, MATPØØL, PCDB, XYCDB, CASECC, any DTI names, and SCRATCH thru SCRATCH9.

Input Data Card EIGB Buckling Analysis Data

Description: Defines data needed to perform buckling analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGB	SID	METHØD	L1	L2	NEP	NDP	NDN	E	+abc
EIGB	13	DET	0.1	2.5	2	1	1	0.0	ABC
+abc	NØRM	G	C						
+BC	MAX								

Field	Contents
SID	Set identification number (Unique Integer > 0)
METHØD	Method of eigenvalue extraction, one of the BCD values "INV", "DET","FEER", "UINV", or "UDET"
	INV - Inverse power method, symmetric matrix operations
	DET - Determinant method, symmetric matrix operations
	FEER - Tridiagonal reduction method, symmetric matrix operations
	UINV - Inverse power method, unsymmetric matrix operations
	UDET - Determinant method, unsymmetric matrix operations
L1,L2	Eigenvalue range of interest (Real; L1 < L2 > 0.0). For METHØD = "FEER", L1 is ignored and L2 is the acceptable relative error tolerance on eigenvalues, (Default is .1/n where n is the order of the stiffness matrix) (Real > 0.0)
NEP	Estimate of number of roots in positive range. Desired number of eigenvalues of smallest magnitude for METHØD = "FEER". (Default is automatically calculated to extract at least one accurate mode) (Integer > 0)
NDP,NDN	Desired number of positive and negative roots (Default = 3 NEP) (Integer > 0) Ignored for METHØD = "FEER"
E	Convergence criteria (optional) (Real > 0.0)
NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT"
	MAX - Normalize to unit value of the largest component in the analysis set
	PØINT - Normalize to unit value of the component defined in fields 3 and 4 (Defaults to "MAX" if defined component is zero)
G	Grid or scaler point identification number (Integer > 0) (Required if and only if NØRM = "PØINT")
C	Component number (One of the integers 1-6) (Required if and only if NØRM = "PØINT" and G is a geometric grid point)

Remarks: 1. Buckling analysis root extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

2. The quantities L1 and L2 are dimensionless and specify a range in which the eigenvalues are to be found. An eigenvalue is a factor by which the prebuckling state of stress (first subcase) is multiplied to produce buckling. If METHØD = "FEER", L1 is ignored and L2 represents the maximum upper bound, in percent, on

$| \lambda_{FEER} / \lambda_{EXACT} - 1 |$ for acceptance of a computed eigensolution.

3. The continuation card is required.

4. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.

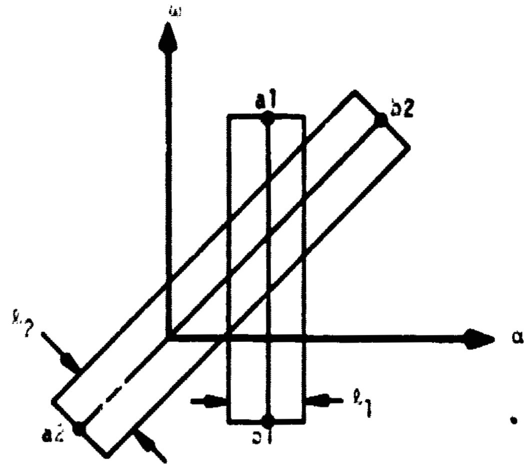
5. If METHØD = "DET", L1 must be greater than or equal to 0.0.

6. If NØRM = "MAX", components that are not in the analysis set may have values larger than unity.

7. If NØRM = "PØINT", the selected component must be in the analysis set.

Input Data Card <u>EIGC</u> Complex Eigenvalue Extraction Data

<u>Description</u>: Defines data needed to perform complex eigenvalue analysis.



<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
EIGC	SID	METHØD	NØRM	G	C	E			+abc
EIGC	14	DET	PØINT	27		1.-8			ABC
+abc	α_{a1}	ω_{a1}	α_{b1}	ω_{b1}	ℓ_1	N_{e1}	N_{d1}		+def
+BC	2.0	5.6	2.0	-3.4	2.0	4	4		DEF
+def	α_{a2}	ω_{a2}	α_{b2}	ω_{b2}	ℓ_2	N_{e2}	N_{d2}		
+EF	-5.5	-5.5	5.6	5.6	1.5	6	3		

(etc.)

<u>Field</u>	<u>Contents</u>
SID	Set identification number (Unique integer > 0)
METHØD	Method of complex eigenvalue extraction, one of the BCD values, "INV", "DET", "HESS", or "FEER" INV - Inverse power method DET - Determinant method HESS - Upper Hessenberg method FEER - Tridiagonal Reduction method

NØRM	Method for normalizing eigenvectors, one of the BCD values "MAX" or "PØINT" MAX - Normalize to a unit value for the real part and a zero value for the imaginary part, the component having the largest magnitude PØINT - Normalize to a unit value for the real part and a zero value for the imaginary part the component defined in fields 5 and 6 - defaults to "MAX" if the magnitude of the defined component is zero.
G	Grid or scalar point identification number (Required if and only if NØRM=PØINT) (Integer > 0)
C	Component number (Required if and only if NØRM="PØINT" and G is a geometric grid point) $(0 \leq \text{integer} \geq 6)$
E	Convergence criterion (optional) (Real $\geq$ 0.0) For method = "FEER", error-tolerance on acceptable eigenvalues (default value is .10/n, where n is the order of the stiffness matrix).
$(\alpha_{aj}, \omega_{aj})$ $(\alpha_{bj}, \omega_{bj})$	Two complex points defining a line in the complex plane (Real) For method = "FEER", $(\alpha_{aj}, \omega_{aj})$ is a point of interest in the complex plane, closest to which the eigenvalues are computed; $\lvert\alpha_{aj}\rvert + \lvert\omega_{aj}\rvert > 0$. The point $(\alpha_{bj}, \omega_{bj})$ is ignored.
ℓ_j	Width of region in complex plane (Real > 0.0) Blank for method = "FEER'.
N_{ej}	Estimated number of roots in each region (Integer > 0) Ignored for method = "FEER".
N_{dj}	Desired number of roots in each region (Default is $3N_{ej}$) (Integer > 0) Desired number of accurate roots for method = "FEER" (Default is 1).

Remarks:

1. Each continuation card defines a rectangular search region. For method = "FEER", the card defines a circular search region, centered at $(\alpha_{aj}, \omega_{aj})$ and of sufficient radius to encompass N_{dj} roots. Any number of regions may be used and they may overlap. Roots in overlapping regions will not be extracted more than once.

2. Complex eigenvalue extraction data sets must be selected in the Case Control Deck (CMETHØD=SID) to be used by NASTRAN.

3. The units of α, ω and ℓ are radians per unit time.

4. At least one continuation card is required.

5. For the determinant method with no damping matrix, complex conjugates of the roots found are not printed.

6. See Section 10.4.4.5 of the Theoretical Manual for a discussion of convergence criteria.

7. For the Upper Hessenberg method, N_{d1} controls the number of fectors computed. Only one continuation card is considered and the (α,ω) pairs, along with the parameters ℓ_1 and N_{e1}, are ignored. Insufficient storage for HESS will cause the program to switch to INV.

8. The error tolerance, E, for the "FEER" method is with regard to

$$\left| \frac{|\bar{p}_i - (\alpha_{aj}, \omega_{aj})|}{|p_i - (\alpha_{aj}, \omega_{aj})|} - 1 \right| \text{ for } [B] \neq [0] \text{ and}$$

$$\left| \frac{|\bar{p}_i^2 - (\alpha_{aj}, \omega_{aj})^2|}{|p^2 - (\alpha_{aj}, \omega_{aj})^2|} - 1 \right| \text{ for } [B] = [0],$$

where $\bar{p}_i$ is a computed eigenvalue and p_i an exact eigenvalue.

Input Data Card EIGR Real Eigenvalue Extraction Data

Description: Defines data needed to perform real eigenvalue analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
EIGR	SID	METHØD	F1	F2	NE	ND	NZ	F	+abc
EIGR	13	DET	1.0	15.6	10	12	0	1.-3	ABC
+abc	NØRM	G	C						
+BC	PØINT	32	4						

Field

SID Set identification number (Unique integer > 0)

METHØD Method of eigenvalue extraction, one of the BCD values "INV", "DET", "GIV", "FEER", "UINV", or "UDET".

INV - Inverse power method, symmetric matrix operations.

DET - Determinant method, symmetric matrix operations.

GIV - Givens method of tridiagonalization.

FEER - Tridiagonal reduction method, symmetric matrix operations.

UINV - Inverse power method, unsymmetric matrix operations.

UDET - Determinant method, unsymmetric matrix operations.

F1,F2 Frequency range of interest (Required for METHØD = "DET", "INV", "UDET", or "UINV") (Real $\geq$ 0.0; F1 $\leq$ F2); If METHOD = GIV, frequency range over which eigenvectors are desired. The frequency range is ignored if ND > 0, in which case the eigenvectors for the first ND positive roots are found. (Real, F1 $\leq$ F2). If METHOD = "FEER", F1 is the center of range of interest (Default is F1 = 0.0) (Real $\geq$ 0.0), and F2 is the acceptable relative error tolerance on frequency-squared, (Default is .1/n where n is the order of the stiffness matrix) (Real > 0.0).

NE Estimate of number of roots in range (Required for METHØD = "DET", "INV", "UDET", or "UINV", ignored for METHØD = "GIV" and "FEER") (Integer > 0).

ND Desired number of roots for METHØD = "DET", "INV", "UDET", or "UINV", (Default is 3 NE) (Integer > 0). Desired number of roots and eigenvectors for METHØD = "FEER" (Default is automatically calculated to extract at least one accurate mode) (Integer > 0).

NZ Number of free body modes (Optional - used only if METHØD = "DET" or "UDET") (Integer $\geq$ 0).

E Mass orthogonality test parameter (Default is 0.0 which means no test will be made) (Real $\geq$ 0.0).

NØRM — Method for normalizing eigenvectors, one of the BCD values "MASS", "MAX" or "PØINT"

MASS - Normalize to unit value of the generalized mass

MAX - Normalize to unit value of the largest component in the analysis set

PØINT - Normalize to unit value of the component defined in fields 3 and 4 - defaults to "MAX" if defined component is zero

G — Grid or scalar point identification number (Required if and only if NØRM="PØINT") (Integer $\geq$ 0)

C — Component number (One of the integers 1-6) (Required if and only if NØRM="PØINT" and G is a geometric grid point)

Remarks:

1. Real eigenvalue extraction data sets must be selected in the Case Control Deck (METHØD = SID) to be used by NASTRAN.

2. The units of F1 and F2 are cycles per unit time. If METHØD = "FEER", F2 represents the maximum upper bound, in percent, on $|\omega^2_{FEER}/\omega^2_{EXACT} - 1|$ for acceptance of a computed eigensolution.

3. The continuation card is required.

4. If METHØD = "GIV", all eigenvalues are found.

5. If METHØD = "GIV", the mass matrix for the analysis set must be positive definite. This means that all degrees of freedom, including rotations, must have mass properties. ØMIT cards may be used to remove massless degrees of freedom.

6. A nonzero value of E in field 9 also modifies the convergence criteria. See Sections 10.3.6 and 10.4.2.2 of the Theoretical Manual for a discussion of convergence criteria.

7. If NØRM = "MAX", components that are not in the analysis set may have values larger than unity.

8. If NØRM = "PØINT", the selected component must be in the analysis set.

9. If METHØD = "GIV" and rigid body modes are present, F1 should be set to zero if the rigid body eigenvectors are desired.

10. The desired number of roots (ND) includes all roots previously found, such as rigid body modes determined with the use of the SUPØRT card, or the number of roots previously checkpointed when restarting and APPENDing the eigenvector file. The APPEND feature is available in the case of the Determinant, Inverse Power and FEER methods of eigenvalue extraction.

Input Data Card ENDDATA

Description: Defines the end of the Bulk Data Deck

Format and Example:

1	2	3	4	5	6	7	8	9	10
ENDDATA									
ENDDATA									

Remarks: 1. This card is required even if no physical data cards exist in the deck.

2. ENDDATA must begin in columns 1 or 2.

3. Failure to include this card will reeult in an operating system termination casued by an input end of file error.

4. Extraneous data cards may be stored after the ENDDATA card except when the INPUT module data follows or when the UMF card FINIS follows or when multiple job steps occur within the same job submittal on the CDC computer.

Input Data Card FLFACT Aerodynamic Physical Data

Description: Used to specify densities, Mach numbers, and reduced frequencies for flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLFACT	SID	F1	F2	F3	F4	F5	F6	F7	ABC
FLFACT	97	.3	.7	3.5					abc
+BC	F8	F9	--etc.--						

Alternate Form:

FLFACT	SID	F1	THRU	FNF	NF	FMID			
FLFACT	201	.200	THRU	.100	11	.133333			

Field	Contents
SID	Set identification number (Unique Integer > 0).
Fi	Aerodynamic factor (Real).

Remarks:

1. These factors must be selected by a FLUTTER data card to be used by NASTRAN.
2. Imbedded blank fields are forbidden.
3. Parameters must be listed in the order in which they are to be used within the looping of flutter analysis.
4. For the alternate method, NF must be greater than 1. F_{mid} must lie between F_1 and F_{NF}, otherwise F_{mid} will be set to $(F_1 + F_{NF})/2$. Then

$$F_i = \frac{F_1(F_{NF}-F_{mid})(NF-i) + F_{NF}(F_{mid}-F_1)(i-1)}{(F_{NF}-F_{mid})(NF-i) + (F_{mid}-F_1)(i-1)} \qquad i = 1,2,\ldots,NF$$

The use of F_{mid} (middle factor selection) allows unequal spacing of the factors. $F_{mid} = 2F_1F_{NF}/(F_1+F_{NF})$ gives equal values to increments of the reciprocal of F_i.

Input Data Card FLUTTER Aerodynamic Flutter Data

Description: Defines data needed to perform flutter analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
FLUTTER	SID	METHØD	DENS	MACH	RFREQ	IMETH	NVALUE	EPS	
FLUTTER	19	K	119	219	319	S	5	1.-4	

Field	Contents
SID	Set identification number (Unique Integer > 0).
METHØD	Flutter analysis method, "K" for K-method, "PK" for P-K method, "KE" for the K-method restricted for efficiency.
DENS	Identification number of an FLFACT data card specifying density ratios to be used in flutter analysis (Integer $\geq$ 0).
MACH	Identification number of an FLFACT data card specifying Mach numbers (m) to be used in flutter analysis (Integer $\geq$ 0).
RFREQ (or VEL)	Identification number of an FLFACT data card specifying reduced frequencies (k) to be used in flutter analysis (Integer > 0); for the p-k method, the velocity.
IMETH	Choice of intepolation method for matrix interpolation (BCD: L = linear, S = surface) (default is S.)
NVALUE	Number of eigenvalues for output and plots (Integer > 0).
EPS	Convergence parameter for k; used in the P-K method (Real)(default = 10^{-3}).

Remarks:
1. The FLUTTER data card must be selected in Case Control Deck (FMETHOD = SID).
2. The density is given by DENS · RHØREF, where RHØREF is the reference value given on the AERØ data card.
3. The reduced frequency is given by $k = (REFC \cdot \omega / 2 \cdot V)$, where REFC is given on the AERØ data card, ω is the circular frequency and V is the velocity.
4. An eigenvalue is accepted in the P-K method when $|k - k_{estimate}| < EPS$.

Input Data Card GRDSET   Grid Point Default

Description: Defines default options for fields 3, 7 and 8 of all GRID cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
GRDSET		CP				CD	PS		
GRDSET		16				32	3456		

Field	Contents
CP	Identification number of default coordinate system in which the locations of the grid points are defined (Integer $\geq$ 0)
CD	Identification number of default coordinate system in which displacements are measured at grid points (Integer $\geq$ 0)
PS	Permanent single-point constraints associated with grid point (any of the digits 1-6 with no imbedded blanks) (Integer $\geq$ 0)

Remarks:

1. The contents of fields 3, 7 or 8 of this card are assumed for the corresponding fields of any GRID card whose fields 3, 7 and 8 are blank. If any of these fields on the GRID card are blank, the default option defined by this card occurs for that field. If no permanent single-point constraints are desired or one of the coordinate systems is basic, the default may be overridden on the GRID card by making one of fields 3, 7 or 8 zero (rather than blank). Only one GRDSET card may appear in the user's Bulk Data Deck.
2. The primary purpose of this card is to minimize the burden of preparing data for problems with a large amount of repetition (e.g., two-dimensional pinned-joint problems).
3. At least one of the entries CP, CD, or PS must be nonzero.

Input Data Card LØADC   Substructure Static Loading Combination

Description: Defines the static load for a substructuring analysis as a linear combination of load sets defined for each basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
LØADC	SID	S	NAME1	ID1	S1	NAME2	ID2	S2	abc
LØADC	27	1.0	WINGRT	5	0.5	FUSELAGE	966	2.5	ABC
+bc			NAME3	ID3	S3	NAME4	ID4	S4	def
+BC			MIDWG	27	1.75	etc.			

Field	Contents
SID	Load set identification number (Integer > 0)
S	Scale factor applied to final load vector (Real)
NAMEi	Basic substructure name (BCD)
IDi	Load set identification number of substructure NAMEi (Integer > 0)
Si	Scale factor (Real)

Remarks:
1. The load vector is combined by:

$$\{P\} = S\sum_i Si\ \{P\}_{IDi}$$

2. The load set identification numbers (IDi) reference the load sets used in Phase 1 to generate the load vectors on the basic substructures.
3. The NAMEi and IDi need not be unique.
4. The LØADC card is the means of specifying a static loading condition in a Phase 2 substructure analysis. The IDi may actually reference temperature loads or element deformation loads defined in Phase 1.
5. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.

Input Data Card MAT1   Material Property Definition

Description: Defines the material properties for linear, temperature-independent, isotropic materials.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MAT1	MID	E	G	NU	RHØ	A	TREF	GE	+abc
MAT1	17	3.+7	1.9+7		4.28	0.19	5.37+2	0.23	ABC
+abc	ST	SC	SS						
+BC	20.+4	15.+4	12.+4						

Field	Contents
MID	Material identification number (Integer > 0)
E	Young's modulus (Real ≥ 0.0 or blank)
G	Shear modulus (Real ≥ 0.0 or blank)
NU	Poisson's ratio (-1.0 < Real ≤ 0.5 or blank)
RHØ	Mass density (Real)
A	Thermal expansion coefficient (Real)
TREF	Thermal expansion reference temperature (Real)
GE	Structural element damping coefficient (Real)
ST, SC, SS	Stress limits for tension, compression and shear (Real) (Required for Property Optimization calculations; otherwise optional if margins of safety are desired.)

Remarks:

1. One of E or G must be positive (i.e., either E > 0.0 or G > 0.0 or both E and G may be > 0.0).

2. If any one of E, G or NU is blank, it will be computed to satisfy the identity E = 2(1+NU)G; otherwise, values supplied by the user will be used.

3. The material identification number must be unique for all MAT1, MAT2 and MAT3 cards.

4. MAT1 materials may be made temperature dependent by use of the MATT1 card.

5. The mass density, RHØ, will be used to automatically compute mass for all structural elements except the two-dimensional bending only elements TRBSC, TRPLT and QDPLT.

6. If E and NU or G and NU are both blank they will be both given the value 0.0.

7. Weight density may be used in field 6 if the value $\frac{1}{g}$ is entered on the PARAM card WTMASS, where g is the acceleration of gravity.

8. Solid elements must not have NU equal to 0.5.

9. Entries for A (thermal expansion coefficient) and TREF (reference temperature) are assumed to be 0.0 when blank. In a heat formulation, A must be overridden by an appropriate entry; TREF may be overridden if desired.

Input Data Card MATS1 Material Stress Dependence

Description: Specifies table references for material properties which are stress-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATS1	MID	R1							+abc
MATS1	17	28							ABC

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
R1	Reference to table identification number (Integer $\geq$ 0 or blank)

Remarks: 1. A blank or zero entry means no table dependence of the referenced quantity, E, on the basic MAT1 card. For this case, the MATS1 card is not required.

2. TABLES1 type tables must be used.

Input Data Card MATT1 Material Temperature Dependence

Description: Specifies table references for isotropic material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT1	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT1	17	32				15			ABC
+abc	R8	R9	R10						
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT1 card (Integer > 0)
Ri	References to table identification numbers (Integer ≥ 0 or blank) for the corresponding fields on the MAT1 card

Remarks:

1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT1 card, and the quantity remains constant.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be sued.
3. Material properties given on a basic MAT1 card are initial values. If two or more quantities are to retain a fixed relationship, then two or more (as required) tables must be input to define the relationship.

Input Data Card MATT2   **Material Temperature Dependence**

Description: Specifies table references for anisotropic material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT2	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT2	17	32				15			ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	62								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT2 card (Integer > 0)
Ri	References to table identification numbers (Integer ≥ 0 or blank) for the corresponding fields on the MAT2 card

Remarks:
1. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT2 card, and the quantity remains constant.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.
3. Material properties given on a basic MATi card are initial values. If two or more quantities are to retain a fixed relationship, then two or more (as required) tables must be input to define the relationship.

Input Data Card MATT3 Material Temperature Dependence

Description: Specifies table references for orthotropic material properties which are temperature-dependent.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT3	MID	R1	R2	R3	R4	R5	R6	R7	+abc
MATT3	23	42			54				ABC
+abc	R8	R9	R10	R11	R12	R13	R14	R15	
+BC	74								

Field	Contents
MID	Material property identification number which matches the identification number on some basic MAT3 card (Integer > 0)
Ri	References to table identification numbers (Integer ≥ 0 or blank) for the corresponding fields on the MAT3 card

Remarks:
1. Blank or zero entries imply no table dependence of the referenced quantity on the basic MAT3 card, and the quantity remains constant.
2. TABLEM1, TABLEM2, TABLEM3 or TABLEM4 type tables may be used.
3. Material properties given on a basic MATi card are initial values. If two or more quantities are to retain a fixed relationship, then two or more (as required) tables must be input to define the relationship.

Input Data Card MATT4 Thermal Material Temperature Dependence

Description: Specifies table reference for temperature dependent thermal conductivity or convective film coefficient.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT4	MID	T(K)							
MATT4	103	73							

Field	Contents
MID	ID of a MAT4 which is to be temperature dependent (Integer > 0)
T(K)	Identification number of a TABLEMi card which gives temperature dependence of the thermal conductivity or convective film coefficient (Integer $\geq$ 0 or blank)

Remarks:
1. The thermal capacity may not be temperature dependent; field 4 must be blank.
2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantity, K, on the MAT4 card is always multiplied by the tabular function. Note that this is different from structural applications.
3. A blank or zero entry means no table dependence of the referenced quantity on the basic MAT4 card. For this case, the MATT4 card is not required.

Input Data Card MATT5 Thermal Material Temperature Dependence

Description: Specifies table references for temperature dependent conductivity matrix.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MATT5	MID	T(KXX)	T(KXY)	T(KXZ)	T(KYY)	T(KYZ)	T(KZZ)		
MATT5	24	73							

Field	Contents
MID	Identification number of a MAT5, which is to be temperature dependent (Integer > 0)
T(K--)	Identification number of a TABLEMi card which gives temperature dependence of the matrix term (Integer $\geq$ 0 or blank)

Remarks:

1. The thermal capacity may not be temperature dependent. Field 9 must be blank.
2. TABLEM1, TABLEM2, TABLEM3, or TABLEM4 type tables may be used. The basic quantities on the MAT5 card are always multiplied by the tabular function. Note that this is different from the structural applications.
3. Blank or zero entries mean no table dependence of the referenced quantity on the basic MAT5 card, and the quantity remains constant.
4. Material properties given on a basic MATi card are initial values. If two or more quantities are to retain a fixed relationship, then two or more (as required) tables must be input to define the relationship.

Input Data Card MKAERØ1 Mach Number - Frequency Table

Description: Provides a table of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAERØ1	m_1	m_2	m_3	m_4	m_5	m_6	m_7	m_8	ABC
MKAERØ1	.1	.7							+ABC
+BC	k_1	k_2	k_3	k_4	k_5	k_6	k_7	k_8	
+BC	.3	.6	1.0						

Field	Contents
m_i	List of Mach numbers (Real; $1 \leq i \leq 8$).
k_j	List of reduced frequencies (Real > 0.0, $1 \leq j \leq 8$).

Remarks:
1. Blank fields end the list, and thus cannot be used for 0.0.
2. All combinations of (m,k) will be used.
3. The continuation card is required.
4. Since 0.0 is not allowed, it may be simulated with a very small number such as 0.0001.

Input Data Card **MKAERØ2** Mach Number - Frequency Table

Description: Provides a list of Mach numbers (m) and reduced frequencies (k) for aerodynamic matrix calculation.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MKAERØ2	m_1	k_1	m_2	k_2	m_3	k_3	m_4	k_4	
MKAERØ2	.10	.30	.10	.60	.70	.30	.70	1.0	

Field	Contents
m_i	List of Mach numbers (Real > 0.0).
k_i	List of reduced frequencies (Real > 0.0).

Remarks:
1. This card will cause the aerodynamic matrices to be computed for a set of parameter pairs.
2. Several MKAERØ2 cards may be in the deck.
3. Imbedded blank pairs are skipped.

Input Data Card MPC   Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPC	SID	G	C	A	G	C	A		abc
MPC	3	28	3	6.2	2		4.29		+B
+bc		G	C	A	-etc.-				
+B		1	4	-2.91					

Field	Contents
SID	Set identification number (Integer > 0)
G	Identification number of grid or scalar point (Integer > 0)
C	Component number - any one of the digits 1-6 in the case of geometric grid points; blank or zero in the case of scalar points (Integer)
A	Coefficient (Real; the first A must be nonzero)

Remarks:
1. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.
2. Forces of multipoint constraint are not recovered.
3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
4. Dependent coordinates on MPC cards may not appear on ØMIT, ØMIT1, SUPØRT, SPC or SPC1 cards; nor may the dependent coordinates be redundantly implied on ASET, ASET1, or MPCADD cards. They also may not appear as dependent coordinates in CRIGD1, CRIGD2, CRIGD3, or CRIGDR elements.

Input Data Card MPCADD Multipoint Constraint Set Definition

Description: Defines a multipoint constraint set as a union of multipoint constraint sets defined via MPC cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
MPCADD	100	2	3	1	6	4			
+bc	S8	S9	-etc.-						

Field	Contents
SID	Set identification number (Integer > 0; ≠ 101 or 102 if axisymmetric)
Sj	Set identification numbers of multipoint constraint sets defined via MPC cards (Integer > 0; SID ≠ Sj)

Remarks:

1. The Sj must be unique.
2. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.
3. Sj may not be the identification number of a multipoint constraint set defined by another MPCADD card.
4. Set identification numbers of 101 or 102 cannot be used in axisymmetric problems.

Input Data Card MPCAX Axisymmetric Multipoint Constraint

Description: Defines a multipoint constraint equation of the form

$$\sum_j A_j u_j = 0$$

for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
MPCAX	SID				RID	HID	C	A	+abc
MPCAX	32				17	6	1	1.0	+1
+abc	RID	HID	C	A	RID	HID	C	A	+def
+1	23	4	2	-6.8					

-etc.-

Field	Contents
SID	Set identification number (Integer > 0; ≠ 101 or 102)
RID	Ring identification number (Integer > 0)
HID	Harmonic identification number (Integer > 0)
C	Component number (1 ≤ Integer ≤ 6)
A	Coefficient (Real; the first A must be nonzero)

Remarks: 1. This card is allowed if and only if an AXIC card is also present.

2. The first coordinate in the sequence is assumed to be the dependent coordinate and must be unique for all equations of the set.

3. Multipoint constraint sets must be selected in the Case Control Deck (MPC=SID) to be used by NASTRAN.

4. Dependent coordinates appearing on MPCAX cards may not appear on ØMITAX, SPCAX, or SUPAX cards.

5. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.

6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card NØLIN1 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\,T(x_j(t)) \ ,$$

where x_j is either a displacement (u_j) or a velocity ($\dot{u}_j$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN1	SID	GI	CI	S	GJ	CJ	T	X	
NØLIN1	21	3	4	2.1	3	1	6		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number if GI is a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number if GJ is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GJ is a scalar or extra point (See Remark 4 below)
T	Identification number of a TABLEDi card (Integer > 0)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLIENAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN1 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.
4. The permissible values for the component number CJ are given in the following table:

x_j \ GJ	Grid point	Scalar or extra point
Displacement (u_j)	1 ≤ Integer ≤ 6	0 or blank
Velocity ($\dot{u}_j$)	11 ≤ Integer ≤ 16	10

Note that velocity components are represented by integers ten greater than the corresponding displacement components.

5. If x_j is a velocity ($\dot{u}_j$), then it is determined from the relation

$$\dot{u}_{j,t} = \frac{u_{j,t} - u_{j,t-1}}{\Delta t} ,$$

where Δt is the time increment and $u_{j,t}$ and $u_{j,t-1}$ are the displacements at time t and at the previous time step respectively.

Input Data Card NØLIN2 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = S\ x_j(t) y_k(t)$$

where x_j and y_k are either displacements (u_j, u_k) or velocities ($\dot{u}_j, \dot{u}_k$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN2	SID	GI	CI	S	GJ	CJ	GK	CK	
NØLIN2	14	2	1	2.9	2	1	2	11	

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number if GI is a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number if GJ is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GJ is a scalar or extra point (See Remark 4 below)
GK	Grid or scalar or extra point identification number (Integer > 0)
CK	Component number if GK is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GK is a scalar or extra point (See Remark 4 below)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN2 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.
4. The permissible values for the component number CJ or CK are given in the following table:

x_j or y_k \ GJ or GK	Grid point	Scalar or extra point
Displacement (u_j or u_k)	1 ≤ Integer ≤ 6	0 or blank
Velocity ($\dot{u}_j$ or $\dot{u}_k$)	11 ≤ Integer ≤ 16	10

Note that velocity components are represented by integers ten greater than the corresponding displacement components.

5. If x_j or y_k is a velocity ($\dot{u}_j$ or $\dot{u}_k$), then it is determined from the relation

$$\dot{u}_{j,t} = \frac{u_{j,t} - u_{j,t-1}}{\Delta t} \quad \text{or} \quad \dot{u}_{k,t} = \frac{u_{k,t} - u_{k,t-1}}{\Delta t}$$

where Δt is the time increment, $u_{j,t}$ and $u_{k,t}$ are the displacements at the time t and $u_{j,t-1}$ and $u_{k,t-1}$ are the displacements at the previous time step.

6. x_j and y_k need not both represent displacements or velocities. One of them may be a displacement and the other may be a velocity.

Input Data Card NØLIN3 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} S(x_j(t))^A, & x_j(t) > 0 \\ 0 , & x_j(t) \le 0 , \end{cases}$$

where x_j is either a displacement (u_j) or a velocity ($\dot{u}_j$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN3	SID	GI	CI	S	GJ	CJ	A	X	
NØLIN3	4	102		-6.1	2	5	-3.5		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number if GI is a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number if GJ is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GJ is a scalar or extra point (See Remark 4 below)
A	Amplification factor (Real)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN3 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.
4. The permissible values for the component number CJ are given in the following table:

x_j \ GJ	Grid point	Scalar or extra point
Displacement (u_j)	1 ≤ Integer ≤ 6	0 or blank
Velocity ($\dot{u}_j$)	11 ≤ Integer ≤ 16	10

Note that velocity components are represented by integers ten greater than the corresponding displacement components.

5. If x_j is a velocity ($\dot{u}_j$), then it is determined from the relation

$$\dot{u}_{j,t} = \frac{u_{j,t} - u_{j,t-1}}{\Delta t}$$

where Δt is the time increment and $u_{j,t}$ and $u_{j,t-1}$ are the displacements at time t and at the previous time step respectively.

Input Data Card NØLIN4 Nonlinear Transient Response Dynamic Load

Description: Defines nonlinear transient forcing functions of the form

$$P_i(t) = \begin{cases} -S(-x_j(t))^A & , \; x_j(t) < 0 \\ 0 & , \; x_j(t) \geq 0 \end{cases}$$

where x_j is either a displacement (u_j) or a velocity ($\dot{u}_j$).

Format and Example:

1	2	3	4	5	6	7	8	9	10
NØLIN4	SID	GI	CI	S	GJ	CJ	A		
NØLIN4	2	4	6	2.0	101		16.3		

Field	Contents
SID	Nonlinear load set identification number (Integer > 0)
GI	Grid or scalar or extra point identification number at which nonlinear load is to be applied (Integer > 0)
CI	Component number if GI is a grid point (0 < Integer ≤ 6); blank or zero if GI is a scalar or extra point
S	Scale factor (Real)
GJ	Grid or scalar or extra point identification number (Integer > 0)
CJ	Component number if GJ is a grid point (0 < Integer ≤ 6; 11 ≤ Integer ≤ 16); blank or zero or 10 if GJ is a scalar or extra point (See Remark 4 below)
A	Amplification factor (Real)

Remarks:

1. Nonlinear loads must be selected in the Case Control Deck (NØNLINEAR=SID) to be used by NASTRAN.
2. Nonlinear loads may not be referenced on a DLØAD card.
3. All coordinates referenced on NØLIN4 cards must be members of the solution set. This means the u_e set for modal formulation and the $u_d = u_e + u_a$ set for direct formulation.
4. The permissible values for the component number CJ are given in the following table:

x_j \ GJ	Grid point	Scalar or extra point
Displacement (u_j)	1 ≤ Integer ≤ 6	0 or blank
Velocity ($\dot{u}_j$)	11 ≤ Integer ≤ 16	10

Note that velocity components are represented by integers ten greater than the corresponding displacement components.

5. If x_j is a velocity ($\dot{u}_j$), then it is determined from the relation

$$\dot{u}_{j,t} = \frac{u_{j,t} - u_{j,t-1}}{\Delta t} ,$$

where Δt is the time increment and $u_{j,t}$ and $u_{j,t-1}$ are the displacements at time t and at the previous time step respectively.

Input Data Card ØMIT1 Omitted Coordinates

Description: Defines coordinates (degrees of freedom) that the user desires to omit from the problem through matrix partitioning. Used to reduce the number of independent degrees of freedom.

Format and Example:

1	2	3	4	5	6	7	8	9	10
ØMIT1	C	G	G	C	G	G	G	G	abc
ØMIT1	3	2	1	3	10	9	6	5	ABC
+bc	G	G	G	-etc.-					
+BC	7	8							

-etc.-

Alternate Form

ØMIT1	C	ID1	"THRU"	ID2					
ØMIT1	0	17	THRU	109					

Field	Contents
C	Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; must be null or zero if point identification numbers are scalar points)
G,ID1,ID2	Grid or scalar point identification number (Integer > 0; ID1 < ID2)

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multi-point constraint relation (MPC card) or as a degree of freedom on a rigid element (CRIGD1, CRIGD2, CRIGD3, CRIGDR), nor may it be referenced on a SPC, SPC1, ØMIT, ASET, ASET1, or SUPØRT card or on a GRID card as permanent single-point constraints.

2. If the alternate form is used, all of the grid (or scalar) points ID1 thru ID2 are assumed.

3. ASET or ØMIT data are not recommended for use in heat transfer analysis with radiation effects.

Input Data Card PAERØ1 Aerodynamic Panel Property

Description: Gives associated bodies for the panels in the Doublet-Lattice method.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PAERØ1	PID	B1	B2	B3	B4	B5	B6		
PAERØ1	1	3							

Field | Contents

PID Property identification number (referenced by CAERØ1) (Unique Integer > 0).

B1,..., B6 ID of associated body (Integer $\geq$ 0 or blank).

Remarks: 1. The associated body must be in the same aerodynamic group (IGID).

2. If there are no bodies, the card is still required.

k. MAXIT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.

l. EPSHT - optional in nonlinear static HEAT transfer analysis (rigid format 3). The real value of this parameter is used to test the convergence of the nonlinear heat transfer solution (see Section 8.4.1 of the Theoretical Manual). The default value is .001.

m. TABS - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the absolute reference temperature. The default value is 0.0.

n. SIGMA - optional in nonlinear static (rigid format 3) and transient (rigid format 9) HEAT transfer analysis. The real value of this parameter is the Stefan-Boltzman constant. The default value is 0.0.

o. BETA - optional in transient HEAT transfer analysis (rigid format 9). The real value of this parameter is used as a factor in the integration algorithm (see Section 8.4.2 of the Theoretical Manual). The default value is 0.55.

p. RADLIN - optional in transient HEAT transfer analysis (rigid format 9). A positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.

q. BETAD - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter is the number of iterations allowed for computing the load correction in the inner (load) loop before shifting to the outer (stiffness) loop which adjusts the differential stiffness. The default value is 4 iterations.

r. NT - optional in static analysis with differential stiffness (rigid format 4). The integer value of this parameter limits the cumulative number of iterations in both loops. The default value is 10 iterations.

s. EPSIØ - optional in static analysis with differential stiffness (rigid format 4). The real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5}.

t. CTYPE - required in cyclic symmetry analysis (rigid formats 14 and 15). The BCD value of this parameter defines the type of cyclic symmetry as follows:

(1) RØT - rotational symmetry
(2) DRL - dihedral symmetry, using right and left halves
(3) DSA - dihedral symmetry, using symmetric and antisymmetric components

u. NSEGS - required in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter is the number of identical segments in the structural model.

v. NLØAD - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter is the number of static loading conditions. The default value is 1.

w. CYCIØ - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the form of the input and output data. A value of +1 is used to specify physical segment representation, and a value of -1 for cyclic transform representation. The default value is +1.

x. CYCSEQ - optional in cyclic symmetry analysis (rigid formats 14 and 15). The integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

PARAM (Cont.)

y. KMAX - optional in static analysis with cyclic symmetry (rigid format 14). The integer value of this parameter specifies the maximum value of the harmonic index. The default value is ALL which is NSEGS/2 for NSEGS even and (NSEGS-1)/2 for NSEGS odd.

z. KINDEX - required in normal modes with cyclic symmetry (rigid format 15). The integer value of this parameter specifies a single value of the harmonic index.

aa. NØDJE - optional in AERØ rigid formats. A positive integer of this parameter inidcates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

ab. P1, P2, and P3 - required in AERØ rigid formats when using NØDJE parameter. See Section 5.5 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2, and P3 are -1,11, and XXXXXXXX, respectively.

ac. VREF - optional in modal flutter analysis (rigid format 10). Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

ad. PRINT - optional in modal flutter analysis (rigid format 10). The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default vlaue is YES.

ae. ISTART - optional in direct and modal transient response (rigid formats 9 and 12). A positive value of this parameter will cause the second (or alternate) starting method to be used (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular. The default value is -1 and will cause the first starting method to be used.

af. KDAMP - optional in AERØ rigid formats. An integer value of -1 causes modal damping terms to be put into the complex stiffness matrix for structural damping. The default is +1.

ag. GUSTAERØ - optional in AERØ rigid formats. An integer value of -1 causes gust loads to be computed. The default is +1.

ah. IFTM - optional in aeroelastic response (rigid format 11). The value of this parameter selects the method for the integration of the Inverse Fourier Transform. The integer value 0 specifies a rectangular fit; 1 specifies a trapezoidal fit; and 2 specifies a cubic spline fit to obtain solutions versus time for which aerodynamic forces are functions of frequency. The default value is 0.

ai. MACH - optional in AERØ rigid formats. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default is 0.0.

aj. Q - required in aeroelastic response (rigid format 11). The real value of this parameter defines the dynamic pressure.

Input Data Card PBAR   Simple Beam Property

Description: Defines the properties of a simple beam (bar) which is used to create bar elements via the CBAR card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PBAR	PID	MID	A	I1	I2	J	NSM		abc
PBAR	39	6	2.9		5.97				123
+bc	C1	C2	D1	D2	E1	E2	F1	F2	def
+23			2.0	4.0					
+ef	K1	K2	I12						

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
A	Area of bar cross-section (Real)
I1, I2, I12	Area moments of inertia (Real, $I_1 I_2 \geq I_{12}^2$)
J	Torsional constant (Real)
NSM	Nonstructural mass per unit length (Real)
K1, K2	Area factor for shear (Real)
Ci, Di, Ei, Fi	Stress recovery coefficients (Real)

Remarks:

1. For structural problems, PBAR cards may only reference MAT1 material cards.
2. See Section 1.3.2 for a discussion of bar element geometry.
3. For heat transfer problems, PBAR cards may only reference MAT4 or MAT5 material cards.
4. The quantities, K1 and K2, are expressed as the relative amounts (0.0 to 1.0) of the total cross-sectional area contributing to the transverse shear stiffnesses (KAG) in the direction of the two principal axes. These quantities are ignored if I12 is non-zero.

Input Data Card PIHEX Isoparametric Hexahedron Property

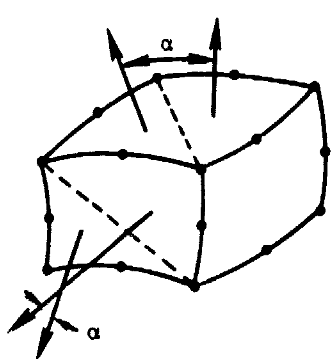
Description: Defines the properties of an isoparametric solid element, including a material reference and the number of integration points. Referenced by the CIHEX1, CIHEX2, and CIHEX3 cards.

Format and Example:

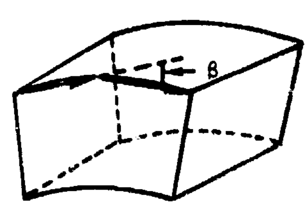
1	2	3	4	5	6	7	8	9	10
PIHEX	PID	MID	CID	NIP	AR	ALFA	BETA		
PIHEX	15	3		3			5.0		

Field	Contents
PID	Property identification number (Integer > 0)
MID	Material identification number (Integer > 0)
CID	Identification number of the coordinate system in which the material referenced by MID is defined (Integer $\geq$ 0 or blank)
NIP	Number of integration points along each edge of the element (Integer = 2, 3, 4 or blank)
AR	Maximum aspect ratio (ratio of longest to shortest edge) of the element (Real > 1.0 or blank)
ALFA	Maximum angle in degrees between the normals of two subtriangles comprising a quadrilateral face (Real, 0.0 $\leq$ ALFA $\leq$ 180.0, or blank)
BETA	Maximum angle in degrees between the vector connecting a corner point to an adjacent midside point and the vector connecting that midside point and the other midside or corner point (Real, 0.0 $\leq$ BETA $\leq$ 180.0, or blank)

Examples of Field Definitions:



Example of ALFA



Example of BETA

Remarks:

1. All PIHEX cards must have unique identification numbers.
2. CID is not used for isotropic materials.
3. The default for CID is the basic coordinate system.
4. The default for NIP is 2 for IHEX1 and 3 for IHEX 2 and IHEX3.
5. AR, ALFA, and BETA are used for checking the geometry of the element. The defaults are:

	AR	ALFA (degrees)	BETA (degrees)
CIHEX1	5.0	45.0	--
CIHEX2	10.0	45.0	45.0
CIHEX3	15.0	45.0	45.0

6. Presently, anisotropic materials are not supported.

BULK DATA DECK

Input Data Card PLIMIT Property Optimization Limits

Description: Defines the maximum and minimum limits for ratio of new property to original property.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PLIMIT	ELTYP	KMIN	KMAX	PID1	PID2	PID3	PID4	PID5	+abc
PLIMIT	RØD	.01	1.5	1	3	5	4	2	+ABC

+bc	PID6	-etc.-							
+BC		-etc.-							

Alternate form:

PLIMIT	ELTYP	KMIN	KMAX	PID1	"THRU"	PIDi			
PLIMIT	ALL	.001	0.05	30	"THRU"	36			

Field	Contents
ELTYP	One of the following element types: RØD, TUBE, BAR, TRMEM, QDMEM, TRPLT, QDPLT, TRBSC, TRIA1, QUAD1, TRIA2, QUAD2, SHEAR, or ALL or blank.
KMIN	Minimum property ratio (Real > 0.0 or blank)
KMAX	Maximum property ratio (Real > KMIN or = 0.0 or blank)
PIDn	List of property identification numbers associated with KMIN and/or KMAX (Integer > 0)

Remarks:
1. This card is not required (Default KMIN = KMAX = 0.0 for ALL elements).
2. All PID values must be unique for each element type.
3. All elements with the same property identification number in the output stress data block, ØES1, have these limits applied if ALL is specified.
4. Property entries optimized depend on the element type and material stress limits. Only nonzero properties with nonzero stress limits are optimized.
5. If KMAX = 0.0, no limit is placed on the maximum change.
6. If ELTYP is blank, ALL is assumed.
7. One of KMIN or KMAX may be blank but not both.

Input Data Card PØINTAX Axisymmetric Point

Description: Defines the location of a point on an axisymmetric ring at which loads may be applied via the FØRCE, FØRCEAX, MØMENT or MØMAX cards and at which displacements may be requested.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PØINTAX	ID	RID	PHI						
PØINTAX	2	3	30.0						

Field	Contents
ID	Point identification number (Unique Integer ~ 0)
RID	Identification number of a RINGAX card (Integer > 0)
PHI	Azimuthal angle in degrees (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. PØINTAX identification numbers must be unique with respect to all other PØINTAX, RINGAX, and SECTAX identification numbers.
3. These points are not subject to constraints via MPCAX, SPCAX, or ØMITAX card.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card **PTRIM6** Linear Strain Triangular Membrane Property

Description: Defines the properties of a linear strain triangular membrane element. Referenced by the CTRIM6 card. No bending properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRIM6	PID	MID	T1	T3	T5	NSM			
PTRIM6	666	999	1.17	2.52	3.84	6.3			

Field

PID Property identification number (Integer > 0)

MID Material identification number (Integer > 0)

T1, T3, T5 Membrane thicknesses at the vertices of the element (Real)

NSM Nonstructural mass per unit area (Real)

Remarks:

1. All PTRIM6 cards must have unique property identification numbers
2. PTRIM6 cards may only reference MAT1 or MAT2 cards.
3. In general, the thickness varies linearly over the triangle. If T3 or T5 is specified 0.0 or blank, it will be set equal to T1.

Input Data Card PTRSHL Higher Order Triangular Shell Element Property

Description: Defines the membrane bending and transverse shear properties of a higher order triangular shell element. Referenced by the CTRSHL card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRSHL	PID	MID1	T1	T3	T5	MID2	I1	I3	abc
PTRSHL	10	20	3.0	6.0	4.0	30	2.25	18.0	PQR
+bc	I5	MID3	TS1	TS3	TS5	NSM	Z11	Z21	def
+QR	5.33	40	2.5	5.0	3.5	50.0	1.5	-1.5	STU
+ef	Z13	Z23	Z15	Z25					
+TU	3.0	-3.0	2.0	-2.0					

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for membrane (Integer > 0)
T1, T3, T5	Thickness at vertices 1, 3, and 5 of the element, respectively (Real ≥ 0.0)
MID2	Material identification number for bending (Integer > 0)
I1, I3, I5	Area moments of inertia per unit width at the vertices 1, 3, and 5 of the of the element, respectively (Real ≥ 0.0)
MID3	Material identification number for transverse shear (Integer ≥ 0)
TS1, TS3, TS5	Transverse shear thickness at the vertices 1, 3, and 5 of the element, respectively (Real ≥ 0.0)
NSM	Nonstructural mass per unit area (Real)
Z11, Z21, Z13, Z23, Z15, Z25	Fiber distances for stress computation at grid points G1, G3, and G5 respectively, positive according to the right-hand sequence defined on the CTRSHL card (Real ≥ 0.0)

Remarks:
1. All PTRSHL cards must have unique property identification numbers.
2. If T3 or T5 are equal to 0.0 or blank, they will be set equal to T1.
3. If I3 or I5 are equal to 0.0 or blank, they will be set equal to I1.
4. If TS3 or TS5 are equal to 0.0 or blank, they will be set equal to TS1.
5. If TS1 is 0.0 or blank, the element is assumed to be rigid in transverse shear.
6. The stresses at the centroid will be computed at the top and bottom fibers. The stresses at G1, G3, and G5 will be computed at the locations defined on the property card (if given).
7. Both continuation cards are required, even if blank.

Input Data Card PTRPLT1 Triangular Plate Property

Description: Defines the bending properties of a higher order triangular plate element. Referenced by the CTRPLT1 card. No membrane properties are included.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PTRPLT1	PID	MID1	R1	R3	R5	MID2	TS1	TS3	abc
PTRPLT1	15	25	20.0	30.0	40.0	35	3.0	1.15	PQR
+bc	TS5	NSM	Z11	Z21	Z13	Z23	Z15	Z25	
+QR	1.0	9.0	1.5	-1.5	2.0	-2.0	+2.5	-2.5	

Field	Contents
PID	Property identification number (Integer > 0)
MID1	Material identification number for bending (Integer > 0)
R1, R3, R5	Area moment of inertia per unit width at the grid points G1, G3, and G5 respectively (Real > 0.0) ; $R1 = T_1^3/12$, $R3 = T_3^3/12$, $R5 = T_5^3/12$ where T_1, T_3, and T_5 are the thicknesses of the element at the vertices, respectively
MID2	Material identification number for transverse shear (Integer > 0)
TS1, TS3, TS5	Transverse shear thicknesses at the grid points G1, G3, and G5, respectively (Real)
NSM	Nonstructural mass per unit area (Real)
Z11, Z21, Z13 Z23, Z15, Z25	Fiber distances for stress computation at grid points G1, G3, and G5, respectively; positive according to the right-hand sequence defined on the CTRPLT1 card (Real)

Remarks:
1. All PTRPLT1 cards must have unique property identification numbers.
2. If TS1 is zero, the element is assumed to be rigid in transverse shear.
3. If TS3 or TS5 is 0.0 or blank, it will be set equal to TS1.
4. If I3 or I5 is 0.0 or blank, it will be set equal to I1.
5. The stresses at the centroid will be computed at the top and bottom fibers. The stresses at G1, G3 and G5 will be computed at the locations defined on the property card (if given).
6. The continuation card is required, even if blank.

Input Data Card PVISC Viscous Element Property

Description: Defines the viscous properties of a one-dimensional viscous element which is used to create viscous elements by means of the CVISC card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
PVISC	PID	C1	C2	X	PID	C1	C2	X	
PVISC	3	6.2	3.94						

Field	Contents
PID	Property identification number (Integer > 0)
C1, C2	Viscous coefficients for extension and rotation (Real)

Remarks:
1. Used for both extensional and rotational viscous elements.
2. Has meaning for dynamics problems only.
3. Viscous properties are material independent; in particular, they are temperature-independent.
4. One or two viscous element properties may be defined on a single card.
5. Used only for direct formulation of dynamic analyses.

Input Data Card QBDY1 Boundary Heat Flux Load

Description: Defines a uniform heat flux into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY1	SID	Q0	EID1	EID2	EID3	EID4	EID5	EID6	abc
QBDY1	109	1.-5	721						ABC
+bc	EID7	-etc.-							def
+BC									

Alternate Form

QBDY1	SID	Q0	EID1	"THRU"	EID2				
QBDY1	109	1.-5	721	THRU	750				

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Heat flux into element (Real)
EIDi	HBDY elements (Integer > 0 or BCD "THRU"; EID1<EID2)

Remarks:

1. QBDY1 cards must be selected in Case Control (LØAD = SID) to be used in statics. The power contributed into an element via this card is given by the equation:

$$P_{in} = [(\text{Effective area}) \cdot Q0 + A] \cdot F(t-\tau) \quad ,$$

where effective area is taken from PHBDY cards and A is taken from DAREA card.

2. QBDY1 cards must be referenced on a TLØAD card for use in transient. The power contributed into an element via this card is given by the equation:

$$P_{in}(t) = [(\text{Effective area}) \cdot Q0 \cdot F(t-\tau) \quad ,$$

where the function of time, $F(t-\tau)$, is specified on a TLØAD1 or TLØAD2 card.

3. Q0 is positive for heat input.

4. If a sequential list of elements is desired, the alternate form may be used but no subsequent data is allowed with this option.

Input Data Card QBDY2   Boundary Heat Flux Load

Description: Defines grid point heat flux into an HBDY element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QBDY2	SID	EID	Q01	Q02	Q03	Q04			
QBDY2	109	721	1.-5	1.-5	2.-5	2.-5			

Field	Contents
SID	Load set identification number (Integer > 0)
EID	Identification number of an HBDY element (Integer > 0)
Q0i	Heat flux at the i^{th} grid point on the referenced HBDY element (Real or blank)

Remarks:

1. QBDY2 cards must be selected in Case Control (LØAD = SID) to be used in statics. The power contributed into each point, i, on an element via this card is given by

$$P_i = AREA_i \cdot Q0_i .$$

2. QBDY2 cards must be referenced on a TLØAD card for use in transient. All connected grid points will have the same time function, but may have individual delays. The power contributed into each point, i, or an element via this card is given by

$$P_i(t) = AREA_i \cdot Q0_i \cdot F(t-\tau_i),$$

where $F(t-\tau_i)$ is a function of time specified on a TLØAD1 or TLØAD2 card.

3. $Q0_i$ is positive for heat flux input to the element.

Input Data Card QVECT Thermal Vector Flux Load

Description: Defines thermal vector flux from a distant source into HBDY elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVECT	SID	Q0	E1	E2	E3	EID1	EID2	EID3	abc
QVECT	333	1.-2	-1.0	0.0	0.0	721	722	723	ABC
+bc	EID4	EID5	-etc.-						def
+BC	724								

-etc.-

Field	Contents
SID	Load set identification number (Integer > 0)
Q0	Magnitude of thermal flux vector (Real)
E1,E2,E3	Vector components (in basic coordinate system) of the thermal vector flux (Real or Integer > 0). The total flux is given by Q = Q0{E1,E2,E3}
EIDi	Element identification numbers of HBDY elements irradiated by the distant source (Integer > 0)

Remarks: 1. For statics, the load set is selected in the Case Control Deck (LØAD = SID). The power contributed into an element via this card is given by

$$P_{in} = -\alpha A(\bar{e}\cdot\bar{n})\cdot Q0,$$

where:

α = absorbtivity
A = area of HBDY element
$\bar{e}$ = vector of real numbers E1, E2, E3 of
$\bar{n}$ = positive normal vector of element, see CHBDY data card description
$(\bar{e}\cdot\bar{n})$ = 0 if the vector product is positive (i.e., the flux is coming from behind the element)

2. For transient analysis, the load set (SID) is selected by a TLØADi card which defines a load function of time. The power contributed into the element via this card is given by

$$P_{\ell}(t) = -\alpha A(\bar{e}(t)\cdot\bar{n})\cdot Q0\cdot F(t-\tau),$$

where:

α,A, and $\bar{n}$ are the same as the statics case
$\bar{e}(t)$ = vector of three functions of time, which may be given on TABLEDi data cards. If E1, E2, or E3 is an integer, it is the table identification number. If E1, E2, or E3 is a real number, its value is used directly; if Ei is blank, its value is zero.
$F(t-\tau)$ is a function of time specified or referenced by the parent TLØAD1 or TLØAD2 card. The value τ is calculated for each loaded point.

QVECT (Cont.)

3. If the referenced HBDY element is of TYPE = ELCYL, the power input is an exact integration over the area exposed to the thermal flux vector.

4. If the referenced HBDY element is of TYPE = REV, the vector should be parallel to the basic z axis.

5. If a sequential list of elements is desired, fields 7, 8, and 9 may specify the first element, the BCD string "THRU", and the last element. No subsequent data is allowed with this option.

Input Data Card QVØL   Volume Heat Addition

Description: Defines a rate of internal heat generation in an element.

Format and Example:

1	2	3	4	5	6	7	8	9	10
QVØL	SID	QV	EID1	EID2	EID3	EID4	EID5	EID6	abc
QVØL	333	1.+2	301	302	303	317	345	416	ABC
+bc	EID7	-etc.-							def
+BC	127								

-etc.-

Alternate form

QVØL	SID	QV	EID1	"THRU"	EID2				
QVØL	333	1.+2	301	THRU	303				

Field	Contents
SID	Load set identification (Integer > 0)
QV	Power input per unit volume produced by a heat conduction element (Real)
EIDi	A list of heat conduction elements (Integer > 0 or BCD "THRU"; EID1<EID2)

Remarks: 1. In statics, the load is applied with the case control request, LØAD = SID. The equivalent power contributed via this card into each grid point, i, connected to each element listed, is given by

$$P_i = QV \cdot VØL_i \quad ,$$

where $VØL_i$ is the portion of the volume associated with point i and QV is positive for heat generation.

2. In dynamics, the load is requested by reference on a TLØADi data card. The equivalent power contributed via this card into each grid point i, connected to each element listed, is

$$P_i = QV \cdot VØL_i \cdot F(t-\tau_i) \quad ,$$

where $VØL_i$ is the portion of the volume associated with point i and $F(t-\tau_i)$ is the function of time defined by a TLØADi card. τ_i is the delay for each point i.

3. If a sequential list of elements is desired, the alternate form may be used but no subsequent data is allowed with this option.

BULK DATA DECK

Input Data Card RADMTX Radiation Matrix

Description: Matrix of radiation exchange coefficients (area times view factor) for nonlinear heat transfer analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RADMTX	INDEX	Fi,i	Fi+1,i	Fi+2,i	Fi+3,i	Fi+4,i	Fi+5,i	Fi+6,i	abc
RADMTX	3	0.	9.3	17.2	16.1	.1	0.	6.2	ABC
+bc	Fi+7,i	-etc.-							def
+BC	6.2								

-etc.-

Field	Contents
INDEX	The column number of the matrix (Integer > 0)
Fi+k,i	The matrix values (Real), starting on the diagonal, continuing down the column. A group of zero's at the bottom of the column may be omitted. A blank field will end the column, which disallows imbedded blank fields.

Remarks:

1. The INDEX numbers go from 1 thru NA, where NA is the number of radiating areas.
2. The radiation exchange coefficient matrix is symmetric, and only the lower triangle is input. Column 1 is associated with the HBDY element first listed on the RADLST card, Column 2 for the ne t, etc. Null columns need not be entered.
3. $$P_i = \sum_{j=1}^{NA} F_{ij} q_j$$

   P_i = total irradiation into element i

   q_j = radiosity (per unit area) at j

   F_{ij} = radiation matrix (units of area)
4. A column may only be specified once.
5. An element identification appearing on a RADLIST card that is not defined on a RADMTX card or is only partially defined, will cause the missing terms of the matrix column to be filled with zeros. This implies an infinite heat sink (radiation loss) is present.

Input Data Card RFØRCE Rotational Force

Description: Defines a static loading condition due to a centrifugal force field.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RFØRCE	SID	G	CID	A	N1	N2	N3		
RFØRCE	2	5		-6.4	0.0	0.0	1.0		

Field	Contents
SID	Load set identification number (Integer > 0)
G	Grid point identification number (Integer $\geq$ 0)
CID	Coordinate system defining rotation direction (Integer $\geq$ 0 or blank)
A	Scale factor for rotational velocity in revolutions per unit time (Real)
N1, N2, N3	Rectangular components of rotation direction vector (Real; $N1^2 + N2^2 + N3^2 > 0.0$) The vector defined will act at point G.

Remarks:

1. G = 0 means the basic coordinate system origin.
2. CID = 0 means the basic coordinate system.
3. Load sets must be selected in the Case Control Deck (LØAD=SID) to be used by NASTRAN.
4. Rotational force sets can be combined with other static loads only by using the LØAD bulk data card.
5. The load vector generated by this card can be printed with an ØLØAD request in the Case Control Deck.
6. For elements with lumped mass, the centrifugal acceleration is calculated at the center of the lumped mass. Grid point offsets of the mass such as those defined with BAR and CØNM2 elements are taken into account.
7. For elements using the coupled "consistent" mass option (CØUPMASS) or those with implicit coupled mass matrices such as IHEXi and TRIAAX elements, the centrifugal accelerations are calculated based on grid point locations. This acceleration vector is then multiplied by the mass matrix to generate loads. Therefore, for greater accuracy, elements near the axis of rotation should be kept small to best represent the actual acceleration field.
8. When applying a rotational force to an axisymmetric element, G and CID must be 0 or blank; N1 and N2 must be 0.0.

Input Data Card RINGAX Axisymmetric Ring

Description: Defines a ring for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
RINGAX	ID		R	Z			PS		
RINGAX	3		2.0	-10.0			162		

Field	Contents
ID	Ring identification number ($1 \leq$ Integer $< 10^6$)
R	Ring radius (Real > 0.0)
Z	Ring axial location (Real)
PS	Permanent single-point constraints (any unique combination of the digits 1-6)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. The number of degrees of freedom defined is (6-PS)•H where H is the harmonic count and PS is the number of digits in field 8. (See AXIC card.)
3. RINGAX identification numbers must be unique with respect to all other PØINTAX, RINGAX and SECTAX identification numbers.
4. The fourth and sixth degrees of freedom must be constrained when transverse shear flexibility is not included for the conical shell.
5. For a discussion of the conical shell problem see Section 5.9 of the Theoretical Manual.
6. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

BULK DATA DECK

Input Data Card SET1 Grid Point List

Description: Defines a set of structural grid points by a list.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SET1	SID	G1	G2	G3	G4	G5	G6	G7	ABC
SET1	3	31	62	93	124	16	17	18	ABC
+BC	G8	--etc.-							
+BC	19								

Field Contents

SID Set of identification numbers (Integer > 0).

G1,G2, etc. List of structural grid points (Integer > 0 or "THRU").

Remarks: 1. These cards are referenced by the SPLINE data cards.

2. When using the "THRU" option, all intermediate grid points must exist. The word "THRU" may not appear in field 3 or 9 (2 or 9 for continuation cards.)

BULK DATA DECK

Input Data Card SET2 Grid Point List

Description: Defines a set of structural grid points in terms of aerodynamic macro elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SET2	SID	MACRØ	SP1	SP2	CH1	CH2	ZMAX	ZMIN	
SET2	3	111	.0	.75	0.	.667	1.0	-3.51	

Field Contents

SID Set identification number (Integer > 0).

MACRØ Element identification number of an aero macro element (Integer > 0).

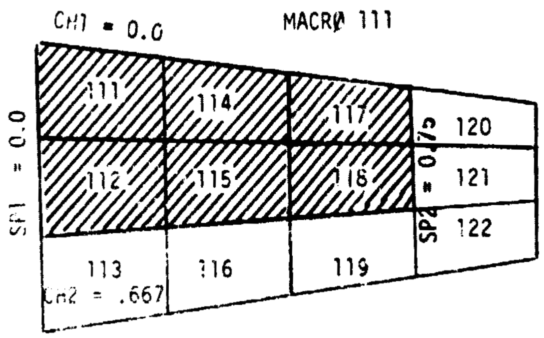
SP1,SP2 Lower and higher span division points defining prism containing set (Real).

CH1,CH2 Lower and higher chord division points defining prism containing set (Real).

ZMAX,ZMIN Top and bottom z coordinates (using right-hand rule with the order the corners as listed on a CAERØi card) of the prism containing set (Real). Usually ZMAX $\geq$ 0, ZMIN $\leq$ 0.

Remarks: 1. These cards are referenced by the SPLINEi data cards.

2. Every grid point, within the defined prism and within the height range, will be in the set. For example,



The shaded area in the figure defines the cross-section of the prism for the sample data given above. Points exactly on the boundary may be missed, hence, to get the area of the macro element, use SP1 = -.01, SP2 = 1.01, etc.

3. A zero value for ZMAX or ZMIN implies infinity is to be used.

4. To find the (internal) grid ID's found, use DIAG 18.

Input Data Card <u>SPC</u> Single-Point Constraint

<u>Description</u>: Defines sets of single-point constraints and enforced displacements.

<u>Format and Example</u>:

1	2	3	4	5	6	7	8	9	10
SPC	SID	G	C	D	G	C	D	X	
SPC	2	32	436	-2.6	5		+2.9		

<u>Field</u>	<u>Contents</u>
SID	Identification number of single-point constraint set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number (Any unique combination of the digits 1-6 (with no imbeded blanks) when point identification numbers are grid points; zero or blank if point identification numbers are scalar points)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

<u>Remarks</u>:

1. A coordinate referenced on this card may <u>not</u> appear as a dependent coordinate in a multipoint constraint relation (MPC card) or as a degree of freedom on a rigid element (CRIGD1, CRIGD2, CRIGD3, CRIGDR), nor may it be referenced on a SPC1, ØMIT, ØMIT1 or SUPØRT card. D must be 0.0 for dynamics problems.
2. Single-point forces of constraint <u>are</u> recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. From one to twelve single-point constraints may be defined on a single card.
5. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.
6. The enforced displacement, D, is used only in static analyses (Rigid Formats 1, 2, 4, 5, 6, 14).
7. In heat transfer analysis, constraints applied to component number 1 are used to fix the temperature at that point.
8. D may be used to define an enforced temperature in static heat transfer analysis (Rigid Format 1 only). See Section 1.8 for methods of defining boundary temperatures in other Rigid Formats.

Input Data Card SPC1 Single-Point Constraint

Description: Defines sets of single-point constraints.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	G1	G2	G3	G4	G5	G6	abc
SPC1	3	2	1	3	10	9	6	5	ABC
+bc	G7	G8	G9	-etc.-					
+BC	2	8							

Alternate Form

1	2	3	4	5	6	7	8	9	10
SPC1	SID	C	GID1	"THRU"	GID2				
SPC1	313	12456	6	THRU	32				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0)
C	Component number (Any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; zero or blank if point identification numbers are scalar points)
Gi, GIDi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. Note that enforced displacements are not available via this card. As many continuation cards as desired may appear when "THRU" is not used.

2. A coordinate referenced on this card may not appear as a dependent coordinate in a multi-point constraint relation (MPC) or as a degree of freedom on a rigid element (CRIGD1, CRIGD2, CRIGD3, CRIGDR), nor may it be referenced on a SPC, ØMIT, ØMIT1, or SUPØRT card.

3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.

4. SPC degrees of freedom may be redundantly specified as permanent constraints on the GRID card.

5. All grid points referenced by GID1 thru GID2 must exist.

6. In heat transfer analysis, constraints applied to component number 1 are used to fix the temperature at a point.

Input Data Card SPCADD Single-Point Constraint

Description: Defines a single-point constraint set as a union of single-point constraint sets defined via SPC or SPC1 cards.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCADD	SID	S1	S2	S3	S4	S5	S6	S7	abc
SPCADD	100	3	2	9	1				
+bc	S8	S9	-etc.-						

-etc.-

Field	Contents
SID	Identification number for new single-point constraint set (Integer > 0; ≠ 101 or 102 if axisymmetric)
Si	Identification numbers of single-point constraint sets defined via SPC or SPC1 cards (Integer > 0; SID ≠ Si)

Remarks:

1. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
2. No Si may be the identification number of a single-point constraint set defined by another SPCADD card.
3. The Si values must be unique.
4. Set identification numbers of 101 or 102 cannot be used in axisymmetric problems.

Input Data Card SPCAX Axisymmetric Single-Point Constraint

Description: Defines sets of single-point constraints for a model containing CCØNEAX, CTRAPAX or CTRIAAX elements.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCAX	SID	RID	HID	C	V				
SPCAX	2	3	4	13	6.0				

Field	Contents
SID	Identification number of single-point constraint set (Integer > 0; ≠ 101 or 102)
RID	Ring identification number (see RINGAX) (Integer ≥ 0)
HID	Harmonic identification number (Integer ≥ 0)
C	Component identification number (any unique combination of the digits 1-6)
V	Enforced displacement value (Real)

Remarks:
1. This card is allowed if and only if an AXIC card is also present.
2. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
3. Coordinates appearing on SPCAX cards may not appear on MPCAX, SUPAX or ØMITAX cards.
4. For a discussion of the conical shell problem, see Section 5.9 of the Theoretical Manual.
5. For a discussion of the axisymmetric solid problem, see Section 5.11 of the Theoretical Manual.

Input Data Card SPCD Enforced Displacement Value

Description: Defines an enforced displacement value for static analysis, which is requested as a LØAD.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCD	SID	G	C	D	G	C	D	X	
SPCD	100	32	436	-2.6	5		+2.9		

Field	Contents
SID	Identification number of a static load set (Integer > 0)
G	Grid or scalar point identification number (Integer > 0)
C	Component number (any unique combination of the digits 1-6 (with no imbedded blanks) when point identification numbers are grid points; zero or blank if point identification numbers are scalar points)
D	Value of enforced displacement for all coordinates designated by G and C (Real)

Remarks:

1. A coordinate referenced on this card must be referenced by a selected SPC or SPC1 data card.
2. Values of D will override the values specified on an SPC bulk data card, if the LØAD set is requested.
3. The bulk data LØAD combination card will not request an SPCD.
4. At least one bulk data LØAD card (FØRCE, SLØAD, etc.) is required in the LØAD set selected in case control.
5. The enforced displacement, D, is used only in static analyses (Rigid Formats 1, 2, 4, 5, 6, 14).
6. In heat transfer analysis, D, is used to define an enforced temperature in statics analysis (Rigid Format 1 only). See Section 1.8 for methods of defining boundary temperatures in other Rigid Formats.

Input Data Card SPCS Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS	SID	NAME	G1	C1	G2	C2	G3	C3	abc
SPCS	61	MIDWG	9	45	18	124	36	456	ABC
+bc	G4	C4	G5	C5	G6	C6	G7	C7	def
+BC	88	136	etc.						

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
Gi	Grid or scalar point identification number in substructure (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.

Remarks:

1. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS1, SPC, SPC1, ØMIT, ØMIT1 or SUPØRT card.
2. Single-point forces of constraint are recovered during stress data recovery.
3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.
4. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

C-4

Input Data Card SPCS1 Substructure Single Point Constraints

Description: Defines a set of single point constraints on a specified basic substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCS1	SID	NAME	C	G1	G2	G3	G4	G5	abc
SPCS1	15	FUSELAGE	1236	1101	1102	1105	THRU	1110	ABC
+bc	G6	G7	G8	G9	G10	G11	G12	G13	def
+BC	1121	1130	THRU	1140	1143	1150	etc.		

Field	Contents
SID	Set identification number (Integer > 0)
NAME	Basic substructure name (BCD)
C	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points
Gi	Grid or scalar point identification numbers (Integer > 0)

Remarks:

1. THRU may appear in fields 6, 7, or 8 of the first card and anywhere in fields 3 - 8 on a continuation card.

2. A coordinate referenced on this card may not appear as a dependent coordinate in a multipoint constraint relation, nor may it be referenced on a SPCS1, SPC, SPC1, ØMIT, ØMIT1 or SUPØRT card.

3. Single-point constraint sets must be selected in the Case Control Deck (SPC=SID) to be used by NASTRAN.

4. All grid points referenced by Gi through Gj must exist.

5. A single G, C pair may not specify all component degrees of freedom for a connected grid point where only some of the degrees of freedom of the grid point have been connected or when some have been disconnected via the RELES card. The degrees of freedom which were connected and those that were not connected must be referenced separately.

Input Data Card SPCSD Substructure Enforced Displacement Values

Description: Defines enforced displacement values for a given substructure during static analysis, which are requested as a LØAD.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPCSD	SID	NAME	G1	C1	D1	G2	C2	D2	
SPCSD	27	LWINGRT	965	3	3.6				

Field	Contents
SID	Identification number of a static load set (Integer > 0)
NAME	Basic substructure name (BCD)
Gi	Grid or scalar point identification number (Integer > 0)
Ci	Component number - Any unique combination of the digits 1 - 6 (with no imbedded blanks) when the Gi are grid points, or null if they are scalar points.
Di	Value of enforced displacement for all coordinates designated by Gi and Ci (Real)

Remarks:

1. A coordinate referenced on this card must be referenced by a selected SPCS or SPCS1 data card.
2. The bulk data LØAD combination card will not request an SPCSD.
3. At least one bulk data load card (LØADC or SLØAD) in addition to the SPCSD cards is required in the LØAD set selected in case control (LØAD = SID).

BULK DATA DECK

Input Data Card SPLINE1 Surface Spline

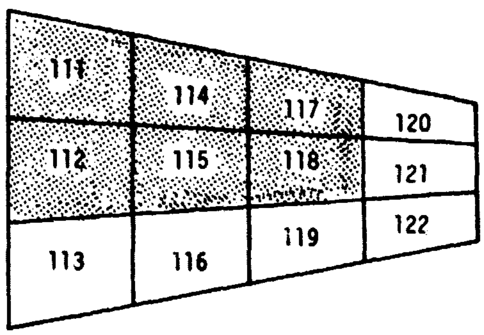
Description: Defines a surface spline for interpolating out-of-plane motion for aeroelastic problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE1	EID	CAERØ	BØX1	BØX2	SETG	DZ			
SPLINE1	3	111	111	118	14	0.			

Field	Contents
EID	Element identification number (unique Integer > 0).
CAERØ	Aero element ID which defines plane of spline (Integer > 0).
BØX1,BØX2	First and last box whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural grid points to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real ≥ 0).

Remarks: 1. The interpolated points (k-set) will be defined by aero-cells. The sketch shows the cells for which u_k is interpolated if BØX1 = 111 and BØX2 = 118.



2. The attachment flexibility (units of area) is used for smoothing the interpolation. If DZ = 0, the spline will pass thru all deflected grid points. If DZ >> (area of spline, a least squares plane fit will occur. Intermediate values will provide smoothing.

BULK DATA DECK

Input Data Card **SPLINE2** Linear Spline

Description: Defines a beam spline for interpolating out-of-plane motion for aeroelastic problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SPLINE2	EID	CAERØ	BØX1	BØX2	SETG	DZ	DTØR	CID	ABC
SPLINE2	5	8	12	24	60	0.	1.0	3	abc
+BC	DTHX	DTHY							
+bc	-1.								

Field	Contents
EID	Element identification number (Unique Integer > 0).
CAERØ	Aero panel or body which is to be interpolated.
ID1, ID2	First and last box or body element whose motions are interpolated using this spline (Integer > 0).
SETG	Refers to a SETi card which lists the structural "g"-set to which the spline is attached (Integer > 0).
DZ	Linear attachment flexibility (Real $\geq$ 0).
DTØR	Torsional flexibility (EI/GJ) (Real > 0; use 1.0 for bodies)
CID	Rectangular coordinate system which defines y-axis of spline (Integer $\geq$ 0)(used for panels only).
DTHX, DTHY	Rotational attachment flexibility (Real). DTHX is for rotation about the x-axis; not used for bodies. DTHY is for rotation about the y-axis; used for slope of bodies.

Remarks:
1. The interpolated points (k-set) will be defined by aero boxes.
2. For panels, the spline axis is the projection of the y-axis of coordinate system CID, projected onto the plane of the panel. For bodies, the spline axis is parallel to the x-axis of the aerodynamic coordinate system.
3. The flexibilities are used for smoothing. Zero attachment flexibility values will imply rigid attachment, i.e., no smoothing. (Negative values in fields 12 and 13 will imply infinity, hence no attachment.
4. A continuation card is required.

Input Data Card SUPØRT Fictitious Support

Description: Defines coordinates at which the user desires determinate reactions to be applied to a free body during analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
SUPØRT	ID	C	ID	C	ID	C	ID	C	
SUPØRT	16	215							

Field	Contents
ID	Grid or scalar point identification number (Integer > 0)
C	Component number (Zero or blank for scalar points; any unique combination of the digits 1-6 for grid points)

Remarks:

1. Coordinates defined on this card may not appear on single-point constraint cards (SPC, SPC1), on omit cards (ØMIT, ØMIT1) or as dependent coordinates in multipoint constraint equations (MPC) or as degrees of freedom on rigid elements (CRIGD1, CRIGD2, CRIGD3, CRIGDR).

2. From one to twenty-four support coordinates may be defined on a single card.

Input Data Card TABDMP1 Structural Damping Table

Description: Defines structural damping as a tabular function of frequency.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABDMP1	ID								abc
TABDMP1	3								ABC

+bc	F_1	G_1	F_2	G_2	F_3	G_3	F_4	G_4	
+BC	2.5	.01057	2.6	.01362	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
F_i	Frequency value in cycles per unit time (Real $\geq$ 0.0)
G_i	Damping value (Real)

Remarks:

1. The F_i must be in either ascending or descending order but not both.
2. Jumps ($F_i = F_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any F_i, G_i entry may be ignored by placing the BCD string "SKIP" in either of two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. The TABDMP1 mnemonic infers the use of the algorithm

$$\boxed{G = g_T(F)}$$

where F is input to the table and G is returned. The table look-up $g_T(F)$ is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $g_T(F)$ is used. There are no error returns from this table look-up procedure.

7. Structural damping tables must be selected in the Case Control Deck (SDAMP=ID) to be used by NASTRAN.
8. Structural damping is used only in modal formulations of complex eigenvalue analysis, frequency response analysis, or transient response analysis.
9. A PARAM, KDAMP, is used in Aeroelastic rigid formats to select the type of damping. See PARAM bulk data card.

Input Data Card TABLED1 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED1	ID								+abc
TABLED1	32								ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	+def
+BC	-3.0	6.9	2.0	5.6	3.0	5.6	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or decending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED1 type tables, this algorithm is

$$\boxed{Y = y_T(X)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TABLED2 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED2	ID	X1							+abc
TABLED2	15	-10.5							ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	+def
+BC	1.0	-4.5	2.0	-4.2	2.0	2.8	7.0	6.5	DEF
+def	X_5	Y_5	X_6	Y_6	X_7	Y_7	X_8	Y_8	+ghi
+EF	SKIP	SKIP	9.0	6.5	ENDT				

(etc.)

Field	Contents
ID	Table identification number (Integer > 0)
X1	Table parameter (Real)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or descending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED2 type tables, this algorithm is

$$\boxed{Y = y_T(X - X1)}$$

where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = X-X1$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TABLED3 Dynamic Load Tabular Function

Description: Defines a tabular function for use in generating frequency-dependent and time-dependent dynamic loads. Also contains parametric data for use with the table.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TABLED3	ID	X1	X2						+abc
TABLED3	62	126.9	30.0						ABC
+abc	X_1	Y_1	X_2	Y_2	X_3	Y_3	X_4	Y_4	+def
+BC	2.9	2.9	3.6	4.7	5.2	5.7	ENDT		

-etc.-

Field	Contents
ID	Table identification number (Integer > 0)
X1, X2	Table parameters (Real; X2 ≠ 0.0)
X_i, Y_i	Tabular entries (Real)

Remarks:

1. The X_i must be in either ascending or descending order but not both.
2. Jumps between two points ($X_i = X_{i+1}$) are allowed, but not at the end points.
3. At least two entries must be present.
4. Any X-Y entry may be ignored by placing the BCD string "SKIP" in either of the two fields used for that entry.
5. The end of the table is indicated by the existence of the BCD string "ENDT" in either of the two fields following the last entry. An error is detected if any continuation cards follow the card containing the end-of-table flag "ENDT".
6. Each TABLEDi mnemonic infers the use of a specific algorithm. For TABLED3 type tables, this algorithm is

$$\boxed{Y = y_T\left(\frac{X - X1}{X2}\right)}$$

   where X is input to the table and Y is returned. The table look-up $y_T(x)$, $x = \frac{X - X1}{X2}$, is performed using linear interpolation within the table and linear extrapolation outside the table using the last two end points at the appropriate table end. At jump points the average $y_T(x)$ is used. There are no error returns from this table look-up procedure.

7. Linear extrapolation is not used for Fourier Transform methods. The function is zero outside the range.

Input Data Card TEMP Grid Point Temperature Field

Description: Defines temperature at grid points for determination of:

1) Thermal loading
2) Temperature-dependent material properties
3) Stress recovery

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMP	SID	G	T	G	T	G	T		
TEMP	3	94	316.2	49	219.8				

Field	Contents
SID	Temperature set identification number (Integer > 0)
G	Grid point identification number (Integer > 0)
T	Temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.

2. From one to three grid point temperatures may be defined on a single card.

3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.

4. If the element material is temperature dependent, its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.

5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.

6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.

7. In heat transfer analysis, the TEMP card is used for the following special purposes:

   a) The Case Control card, TEMP(MATERIAL), will select the initial estimated temperature field for nonlinear conductivity and radiation effects. See Section 1.8.

   b) Boundary temperatures are defined in Rigid Format 3, HEAT by the Case Control card, TEMP(MATERIAL). These points are specified with SPC cards.

   c) The Case Control card, IC, will select the initial conditions, i.e., grid point temperatures, in transient analysis.

Input Data Card TEMPD Grid Point Temperature Field Default

Description: Defines a temperature default for all grid points of the structural model which have not been given a temperature on a TEMP card.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TEMPD	SID	T	SID	T	SID	T	SID	T	
TEMPD	1	216.3							

Field	Contents
SID	Temperature set identification number (Integer > 0)
T	Default temperature (Real)

Remarks:

1. Temperature sets must be selected in the Case Control Deck (TEMP=SID) to be used by NASTRAN.
2. From one to four default temperatures may be defined on a single card.
3. If thermal effects are requested, all elements must have a temperature field defined either directly on a TEMPP1, TEMPP2, TEMPP3, or TEMPRB card or indirectly as the average of the connected grid point temperatures defined on the TEMP or TEMPD cards. Directly defined element temperatures always take precedence over the average of grid point temperatures.
4. If the element material is temperature dependent its properties are evaluated at the average temperature. In the case of isoparametric hexahedron elements, their properties are evaluated at the temperature computed by interpolating the grid point temperatures.
5. Average element temperatures are obtained as a simple average of the connecting grid point temperatures when no element temperature data are defined.
6. Set ID must be unique with respect to all other LØAD type cards if TEMP(LØAD) is specified in Case Control Deck.
7. In heat transfer analysis, the TEMP card is used for the following special purposes:
   a) The Case Control card, TEMP(MATERIAL), will select the initial estimated temperature field for nonlinear conductivity and radiation effects. See Section 1.8.
   b) Boundary temperatures are defined in Rigid Format 3, HEAT, by the Case Control card, TEMP(MATERIAL). These points are specified with SPC cards.
   c) The Case Control card, IC, will select the initial conditions, i.e., grid point temperatures, in transient analysis.

Input Data Card TIC Transient Initial Condition

Description: Defines values for the initial conditions of coordinates used in Transient analysis. Both displacement and velocity values may be specified at independent coordinates of the structural model.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TIC	SID	G	C	UO	VO				
TIC	1	3	2	5.0	-6.0				

Field	Contents
SID	Set identification number (Integer > 0)
G	Grid or scalar or extra point identification number (Integer > 0)
C	Component number (Blank or zero for scalar or extra points, any one of the digits 1-6 for a grid point)
UO	Initial displacement value (Real)
VO	Initial velocity value (Real)

Remarks:

1. Transient initial condition sets must be selected in the Case Control Deck (IC=SID) to be used by NASTRAN for structural analysis; however this card should not be used to define initial temperatures in heat transfer analysis. (See Section 2.3.)

2. If no TIC set is selected in Case Control Deck, all initial conditions are assumed zero.

3. Initial conditions for coordinates not specified on TIC cards will be assumed zero.

4. Initial conditions may be used only in direct formulation.

Input Data Card TLØAD1 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \{A\ F(t - \tau)\}$$

for use in transient response problems.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD1	SID	L	M		TF				
TLØAD1	5	7	9		13				

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set and/or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
TF	Identification number of TABLEDi card which gives $F(t - \tau)$ (Integer > 0)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD1 loads may be combined with TLØAD2 loads only by specification on a DLØAD card. That is, the SID on a TLØAD1 card may not be the same as that on a TLØAD2 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.
6. Field 3 may reference sets containing QHBDY, QBDY1, QBDY2, QVECT, and QVØL cards when using the heat transfer option.
7. If the heat transfer option is used, the referenced QVECT data card may also contain references to functions of time, and therefore A may be a function of time.
8. Fourier analysis will be used if this is selected in an Aeroelastic Response Problem.

Input Data Card TLØAD2 Transient Response Dynamic Load

Description: Defines a time-dependent dynamic load of the form

$$\{P(t)\} = \begin{cases} \{0\}, \tilde{t} < 0 \text{ or } \tilde{t} > T2 - T1 \\ \left\{A\, \tilde{t}^{B}\, e^{C\tilde{t}} \cos(2\pi F\tilde{t} + P)\right\}, \quad 0 \le \tilde{t} \le T2 - T1 \end{cases}$$

for use in transient response problems where $\tilde{t} = t - T1 - \tau$.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TLØAD2	SID	L	M		T1	T2	F	P	abc
TLØAD2	4	10	7		2.1	4.7	12.0	30.0	+12
+bc	C	B							
+12	2.0	3.0							

Field	Contents
SID	Set identification number (Integer > 0)
L	Identification number of DAREA card set and/or a thermal load set which defines A (Integer > 0)
M	Identification number of DELAY card set which defines τ (Integer $\geq$ 0)
T1	Time constant (Real $\geq$ 0.0)
T2	Time constant (Real, T2 > T1)
F	Frequency in cycles per unit time (Real $\geq$ 0.0)
P	Phase angle in degrees (Real)
C	Exponential coefficient (Real)
B	Growth coefficient (Real)

Remarks:

1. If M is zero, τ will be zero.
2. Field 5 must be blank.
3. Dynamic load sets must be selected in the Case Control Deck (DLØAD=SID) to be used by NASTRAN.
4. TLØAD2 loads may be combined with TLØAD1 loads only by specification on a DLØAD card. That is, the SID on a TLØAD2 card may not be the same as that on a TLØAD1 card.
5. SID must be unique for all TLØAD1, TLØAD2, RLØAD1 and RLØAD2 cards.

TLØAD2 (Cont.)

6. Field 3 may reference load sets containing QHBDY, QBDY1, QBDY2, QVECT, QVØL and SLØAD cards when using the heat transfer option.

7. If the heat transfer option is being used, the referenced QVECT load card may also contain references to functions of time, and therefore A may be a function of time.

8. Fourier analysis will be used if this selection is an Aeroelastic Response problem.

Input Data Card TRANS   Component Substructure Transformation Definition

Description: Defines the location and orientation of the component substructure basic coordinate system axes relative to the basic coordinate system of the substructure formed as a result of the substructure CØMBINE operation. The translation and rotation matrices are defined by specifying the coordinates of three points A, B, C. The coordinates of points A, B, C must be expressed on this card in the basic coordinate system of the resultant combined substructure as follows:

A - defines the location of the origin of the basic coordinate system of the component substructure.

B - defines the location of a point on the z axis of the basic coordinate system of the component substructure.

C - defines the location of a point in the positive x side of the xz plane of the basic coordinate system of the component substructure.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TRANS	CID		A1	A2	A3	B1	B2	B3	abc
TRANS	1		0.0	0.0	0.0	0.0	-0.5	10.0	ABC
+bc	C1	C2	C3						
+BC	0.0	10.0	0.5						

Field	Contents
CID	Set identification number (Integer > 0)
A1, A2, A3 B1, B2, B3 C1, C2, C3	Coordinates of the points defining system as described above.

Remarks:
1. Continuation card must be present.
2. Coordinates A, B, C are given in BASIC coordinate system of the result substructure.
3. The value of CID must be unique with respect to all other TRANS data cards.
4. Transformation sets for a whole substructure must be selected in the Substructure Control Deck (TRANS=SID) to be used by NASTRAN. Note that 'TRANS' is a subcommand of the substructure CØMBINE command.
5. Transformation of individual grid points in a substructure prior to combining them is requested by the GTRAN Bulk Data card which references the TRANS information.
6. The three points (A1,A2,A3), (B1,B2,B3), (C1,C2,C3) must be unique and non-collinear.

Input Data Card TSTEP Transient Time Step

Description: Defines time step intervals at which solution will be generated and output in Transient Analysis.

Format and Example:

1	2	3	4	5	6	7	8	9	10
TSTEP	SID	N(1)	DT(1)	NØ(1)					+abc
TSTEP	2	10	.001	5					+ABC
+abc		N(2)	DT(2)	NØ(2)					+def
+ABC		9	0.01	1					+DEF

(etc.)

Field	Contents
SID	Set identification number (Integer > 0)
N(i)	Number of time steps of value DT(i) (Integer ≥ 2)
DT(i)	Time increment (Real > 0.0)
NØ(i)	Skip factor for output (Every NØ(i)$^{\underline{th}}$ step will be saved for output) (Integer > 0)

Remarks: 1. TSTEP cards must be selected in the Case Control Deck (TSTEP=SID) in order to be used by NASTRAN.

2. In Aeroelastic Response problems, this card is required only when TLØAD is requested, i.e., when Fourier methods are selected.

2.5 USER'S MASTER FILE

As a means of aiding the user in handling the large (several boxes of cards) Bulk Data Decks which are typical of NASTRAN problems, the User's Master File is provided for storage of many Bulk Data Decks on a single tape. In the context of this Section, a "tape" is synonomous with both a physical tape or a disk file. (See Section 2.1 for the use of the FILES parameter on the NASTRAN card.)

There are many advantages to using a Master File. The User's Master File provides a convenient common source of data. Errors due to card handling are sharply reduced since a several box input deck is reduced to a few cards. Finally, the convenience to the user in submitting jobs should be emphasized.

2.5.1 Use of User's Master File

Functionally, the User's Master File exhibits all of the properties of an Old Problem Tape (ØPTP) which would result if a job were terminated after the NASTRAN preface; only the control cards used are different. Thus the User's Master File (UMF) becomes an alternate source of bulk data input to NASTRAN which may be modified in identically the same way as bulk data is changed during a modified restart. Since the UMF is used as an alternate ØPTP functionally, only one or the other may appear in a run. The UMF, then, is used only for an initial run and may not be used in conjunction with a restart. The checkpoint feature may be used with a UMF run, however, and the resulting New Problem Tape (NPTP) may be used as an ØPTP in a subsequent restart.

In describing the use of the User's Master File, the UMF control cards will be contrasted with their ØPTP counterparts. In place of the setup card for the ØPTP tape (see Section 5 of the Programmer's Manual for a discussion of these machine and installation dependent NASTRAN driver control cards), use a setup card for the selected UMF tape. In place of the restart dictionary in the Executive Control Deck, use the card

$$\text{UMF}\ \ k_1, k_2$$

described in Section 2.2.1, which selects Bulk Data Deck k_2 from UMF tape k_1 to use in the current execution.

2.5.2 Using the User's Master File Editor

To assist the NASTRAN user in creating and maintaining User's Master Files, an auxiliary NASTRAN preface module, the User's Master File Editor, is provided. The functions performed by the Editor are:

1. Create a New User's Master File (NUMF) from Bulk Data Decks supplied by the user.
2. List and/or punch Bulk Data Decks from an already existing UMF.
3. Edit Bulk Data Decks (which may be modified) from an old UMF onto a NUMF.

Bulk Data Decks must be acceptable to the NASTRAN preface (XSØRT and IFP) to be accepted by the Editor.

The executive control card that causes NASTRAN to execute as the User's Master File Editor is UMFEDIT. When in the Editor mode, NASTRAN executes only the preface. A separate run is required to use a User's Master File generated by the Editor. Preface module UMFEDT, which is where the User's Master File Editor actions occur, reads data cards from the System Input Stream which are used to control Editor activity. Some of these data cards precede the Bulk Data Deck being processed while others follow. The remainder of this section will be devoted to describing these cards and the action caused by them. Section 2.5.3 gives some rules to be followed when making up data cards for the Editor. Several examples will then be given in Section 2.5.4 to illustrate the functions performed by the User's Master File Editor.

Table 1 shows the Editor data cards and describes the action taken for each one. Three classes are described, depending on the tapes used. The cards are free-field format as are the executive control cards and case control cards previously described. The symbolic quantities tid and pid are each up to 8 arbitrarily selected integers chosen by the user who causes the User's Master File to be created. Table 2 shows a summary of Editor control cards.

When a New User's Master File (NUMF) is created, the User's Master File Editor (UMFEDIT) punches the Executive Control cards that are needed to read the decks from the newly created master file. The UMFEDIT automatically punches one UMF Executive Control card for each Bulk Data Deck that is written on the NUMF and lists it in a table of contents.

2.6 USER GENERATED INPUT

It may happen that a user will want to take a problem previously run on another program and run it using NASTRAN. In many instances, this provides the user with the quickest means of familiarizing himself with NASTRAN since he is running a problem which he understands intimately. Also, he may wish to extend his analysis of some previously analyzed problem into regions which previous programs would not allow. In either event, he is faced with the problem of Input Data conversion.

The simplest way to convert structural model data is to write a small FØRTRAN (or other language) program to read in the data cards composing the input data deck for the previous program and punch a new NASTRAN Bulk Data Deck. Usually, the information is in a one to one correspondence, and this procedure is quite straight forward, requiring only a minimal knowledge of programing. While a large deck of cards may result, by using the User's Master File feature described in Section 2.5, the amount of large deck handling may be minimized.

2.6.1 Utility Module INPUT Usage

NASTRAN has implemented one data generating utility module within its existing structure for specific cases. General characteristics of the INPUT module are as follows:

1. INPUT allows the user of NASTRAN to generate the majority of the bulk data cards for a number of selected test problems without having to actually input the physical cards into the Bulk Data Deck.

2. The test problems for which partial data are generated by INPUT are:

   a. N x N Laplace Network from scalar elements

   b. W x L Rectangular Frame from BAR elements or RØD elements

   c. W x L Rectangular Array of QUAD1 elements

   d. W x L Rectangular Array of TRIA1 elements

   e. N - segment string from scalar elements

   f. N - cell beam made from BAR elements

   g. N - scalar point full matrix with optional unit loading

   h. N - spoke wheel

   These problem types are described separately in the following sections.

3. To use INPUT variations of the following alter deck must be used:

```
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT,    ,,,,/G1,G2,----,G5/C,N,a/C,N,b/C,N,b $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE----/ G5,GEØM5/TRUE $
ENDALTER
```

The specific data blocks that need be included depend on the particular problem as do the parameter values. Examples for each problem type will be given.

4. Data cards are read by INPUT from the System Input File using FØRTRAN I/Ø, each card containing up to 10 eight column fields. Remember to right-justify this data. The required data are described in each problem type description.

5. The INPUT data card(s) follow the ENDDATA card. Do not "store" other data that is not intended to be used by the INPUT module.

6. Several sample problems were run as part of checkout. The input for these runs are available as examples of INPUT usage.

7. Restart tables are not effective with respect to "cards" generated by INPUT since the preface is unaware of their existance.

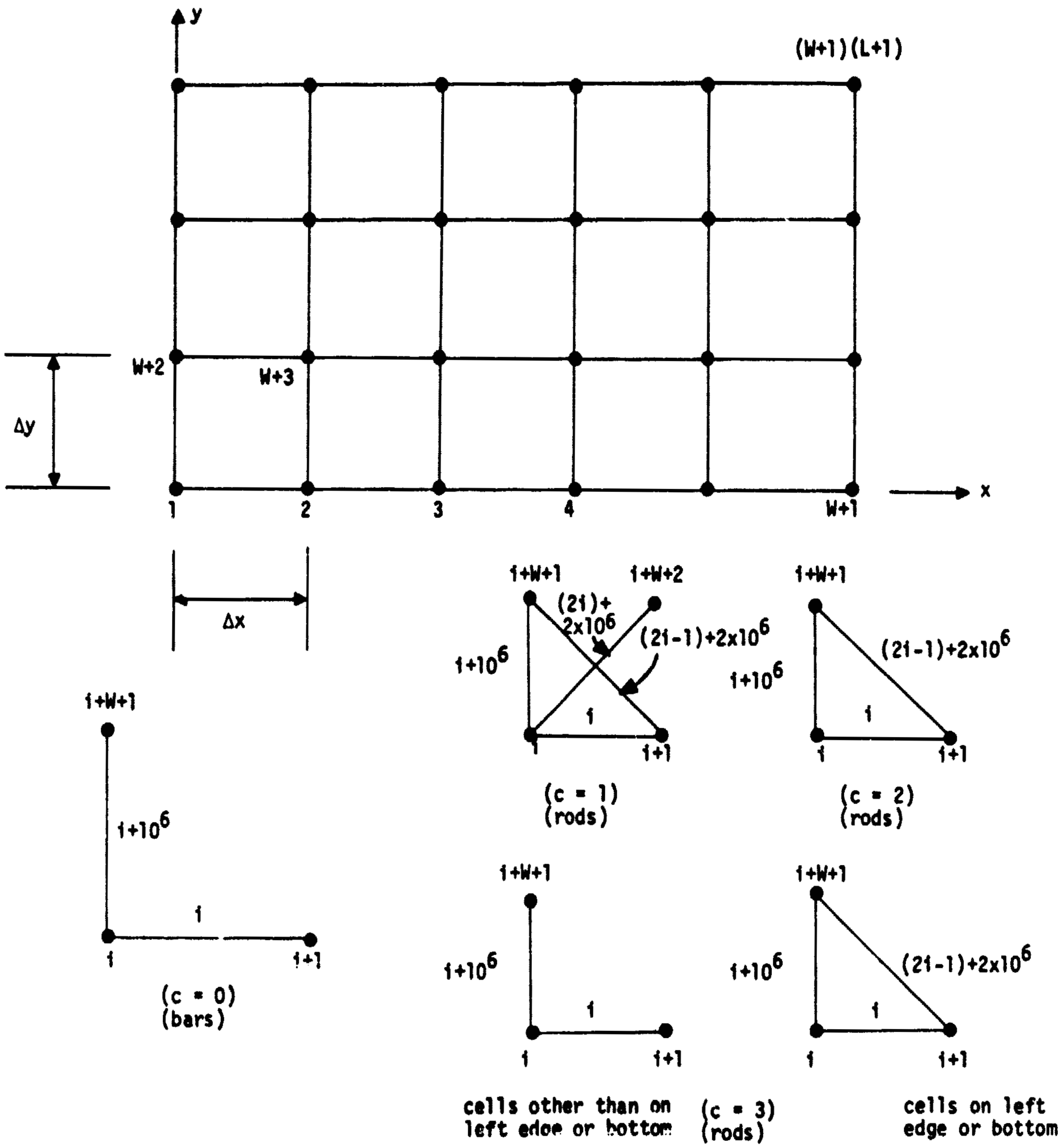
8. The INPUT data generator feature is restrictive. It can only be used in the circumstances illustrated. The user may employ the INPUT module as described but merging of user data with INPUT data is not supported. As an example, single point constraints may be defined either in the bulk data deck or in the INPUT module data deck but not both places in an attempt to combine them. Thus if SPC cards are defined in the bulk data deck, then the G4 data block will not be generated and GEØM4 must not be equivalenced to G4.

2.6.1.1 Laplace Circuit (a=1, b=1,2 or 3, c is not used)

INPUT generates CELAS4, SPC (for b=1), and CMASS (for b=2,3) cards for the circuit shown.

2.6.1.2 Rectangular Frame made from BAR's or RØD's (a=2, b=1,2,3 or 4, c=0,1,2 or 3)

INPUT generates GRID, CBAR or CRØD and SEQGP cards for the rectangular frame shown.



NASTRAN DATA DECK

a. Data Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	P	(I8)	Permanent single-point constraints

b. Options (SEQGP cards)

b
- =1, Regular Banding (no SEQGP cards generated)
- =2, Double Banding
- =3, Active Columns
- =4, Reverse Double Banding

c
- =0, Bars
- =1, Rods with both diagonals
- =2, Rods with UL - LR diagonals
- =3, Rods - statically determinate

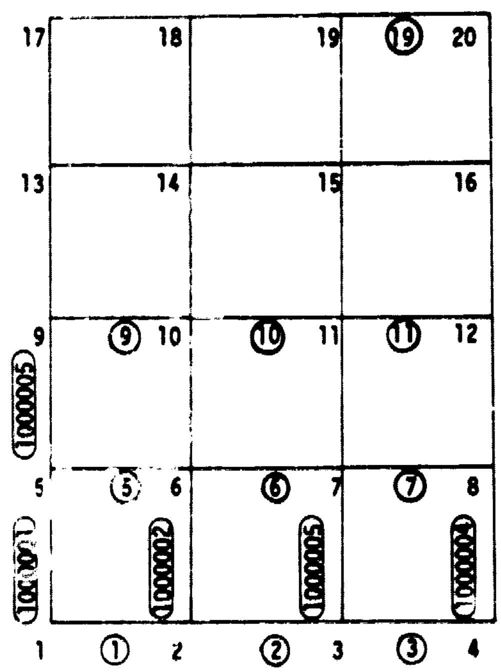
c. Notes

(1) A PBAR card with PID of 101 must be supplied as part of the Bulk Data for c = 0; for c ≠ 0, this is a PRØD card.

(2) If b = 1, SEQGP cards may be included in the Bulk Data.

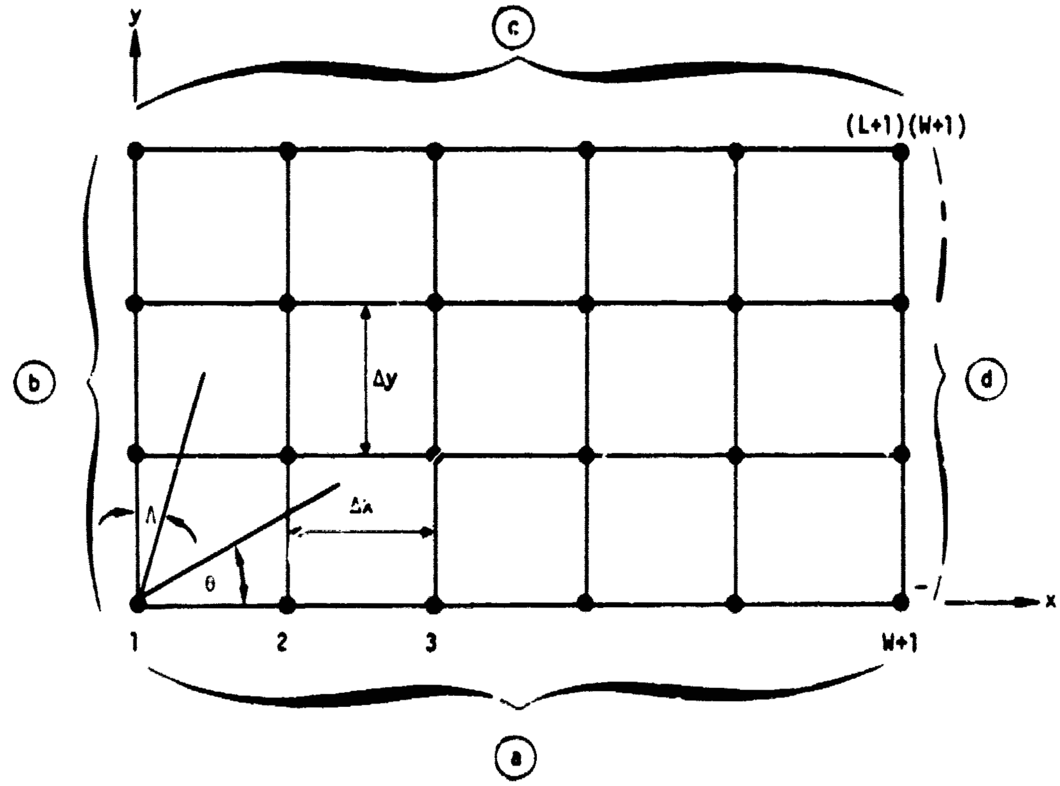
USER GENERATED INPUT

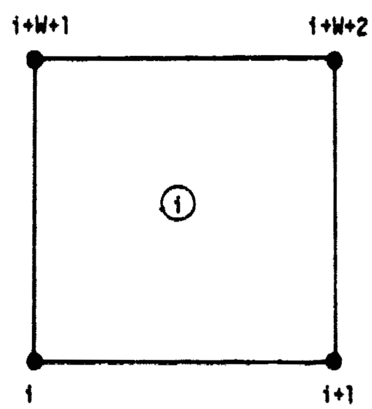
```
ID INPUT, CASE2
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NOP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,,/C,N,2/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR FRAME FRØM BARS
LABEL=REGULAR BANDING
SPC=1
LØAD=1
ØUTPUT
SET 101 = 1,4,17,20
DISP=101
BEGIN BULK
FØRCE          1      20       0     1.0     1.0     0.0     0.0
MAT1           7     1.0     1.0
PBAR         101       7     1.0     2.0     4.0     8.0
SPC            1       1    1234     0.0       4      23     0.0
ENDDATA
       3       4     1.0     2.0     3.[illegible]
```



2.6.1.3 Rectangular Plate made from QUAD1's (a=3, b=1,2,3 or 4, c is not used)

INPUT generates GRID, CQUAD1, SEQGP, ØMIT (if requested), and SPC (if requested) cards for the rectangular grid work shown.





USER GENERATED INPUT

a. Data Deck (2 cards required)

First Card

1	W	(I8)	No. cells in x-direction
2	L	(I8)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(I8)	Permanent Constraints
6	Λ	(E8.0)	Sweep angle in degrees
7	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IY0	(I8)	SPC's on y = 0
2	IX0	(I8)	SPC's on x = 0
3	IYL	(I8)	SPC's on $y = L \cdot \Delta y$
4	IXW	(I8)	SPC's on $x = W \cdot \Delta x$
5	IØX	(I8)	ØMIT's in x-direction
6	IØY	(I8)	ØMIT's in y-direction

b. Options (SEQGP cards)

b =1, Regular banding (no SEQGP cards generated)
=2, Double banding
=3, Active banding
=4, Reverse double banding

c. Notes

(1) If IP, IYØ, IXØ, IYL, IXW, IØX, and IØY are all zero, data block G4 will be purged.

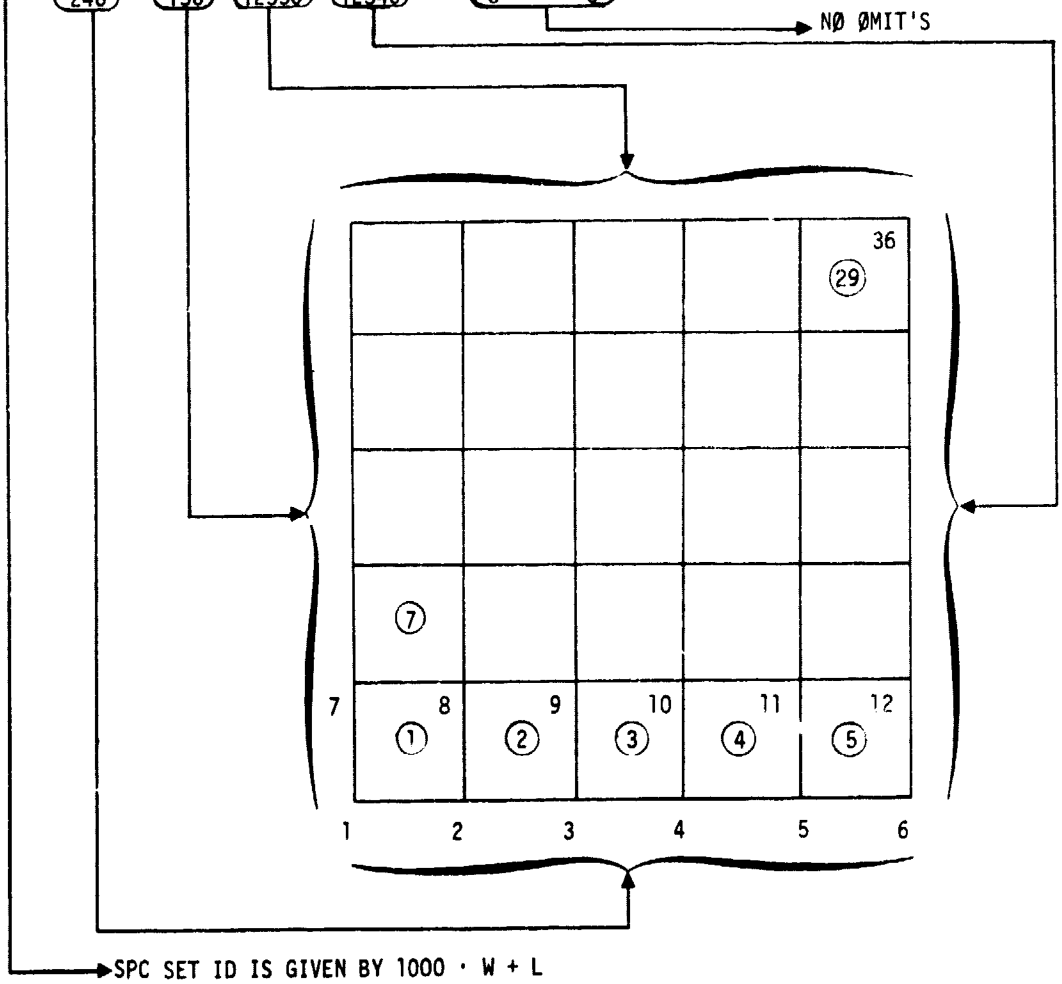
(2) A PQUAD1 card with PID = 101 must be included in the Bulk Data.

(3) IF SPCs are generated the set ID will be 1000NX + NY.

(4) If b = 1, SEQGP cards may be included in the Bulk Data.

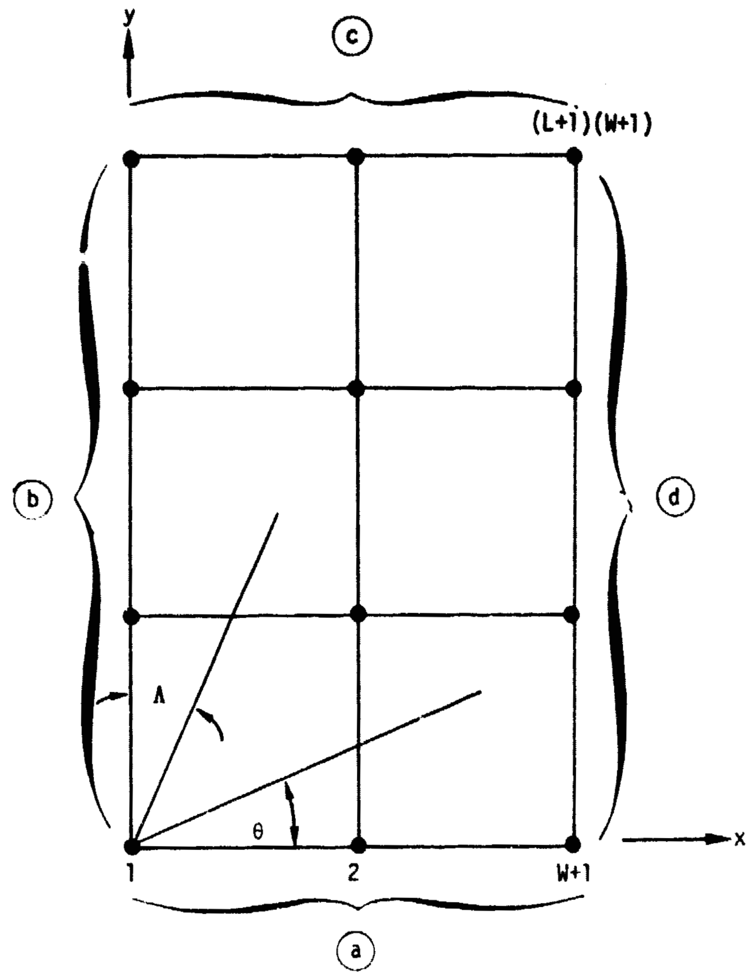
NASTRAN DATA DECK

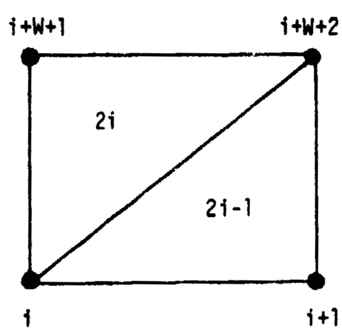
```
ID INPUT, CASE3
TIME 30
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/G1,G2,,G4,/C,N,3/C,N,1 $
EQUIV G1,GEØM1/TRUE  /  G2,GEØM2/TRUE  /  G4,GEØM4/TRUE  $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=RECTANGULAR PLATE MADE FRØM CQUAD1'S
LABEL=STATICS            SIMPLE SUPPØRTS       REGULAR BAND
SPC=5005
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
FØRCE   1       1       0       1.0     0.0     0.0     1.0
MAT1    7       1.0     1.0
PQUAD1  101     7       1.0     7       2.0     7       4.0
ENDDATA
       5        5      10.0    10.0      126     0.0
      246      156    12356   12346      0        0
```



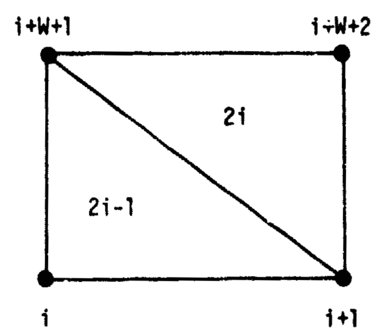
2.6.1.4 Rectangular Plate made from TRIA1's (a=4, b=1,2,3 or 4, c is not used)

INPUT generates GRID, CTRIA1, SEQGP, and SPC (if requested) cards for the rectangular grid work shown.





(c = 1)



(c = 2)

a. Data Deck (2 cards required)

First Card

1	W	(18)	No. cells in x-direction
2	L	(18)	No. cells in y-direction
3	Δx	(E8.0)	Length of cell in x-direction
4	Δy	(E8.0)	Length of cell in y-direction
5	IP	(18.0)	Permanent constraints
6	Λ	(E8.0)	Sweep angle in degrees
7	θ	(E8.0)	Material orientation angle in degrees

Second Card

1	IYO	(18)	SPC's on $y = 0$
2	IXO	(18)	SPC's on $x = 0$
3	IYL	(18)	SPC's on $y = L \cdot \Delta y$
4	IXW	(18)	SPC's on $x = W \cdot \Delta x$

b. Options (SEQGP cards)

$$b \begin{cases} =1, \text{ Regular banding (no SEQGP cards generated)} \\ =2, \text{ Double banding} \\ =3, \text{ Active banding} \\ =4, \text{ Reverse double banding} \end{cases}$$

c. Notes

(1) If IP, IYO, IXO, IYL and IXW are all zero, G4 will be purged.

(2) A PTRIA1 card with PID=101 must be included in the Bulk Data.

(3) If SPCs are generated the set ID will be 1000NX + NY.

(4) If b=1, SEQGP cards may be included in the Bulk Data.

USER GENERATED INPUT

a. Data Card

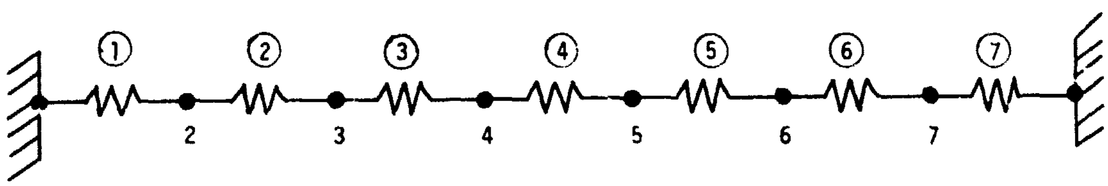
1	N	(I8)	No. of segments
2	k_1	(E8.0)	Spring value
3	k_2	(E8.0)	Spring value (if zero, none of these elements are generated)
4	m	(E8.0)	Mass value (if zero, none of these elements are generated)
5	b	(E8.0)	Damper values (if zero, none of these elements are generated)

b. Notes

(1) If any of k_2, m, or b are zero, those elements will not be generated.

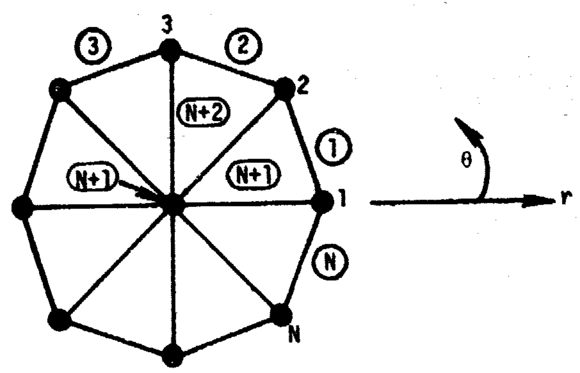
NASTRAN DATA DECK

```
ID INPUT, CASE 5
TIME 30
APP DISP
SØL 1,3
ALTER 1
.ARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT, ,,,,/,G2,,,/C,N,5 $
EQUIV G2,GEØM2/TRUE $
ENDALTER
CEND
ECHØ=BØTH
TITLE=TEST ØF UTILITY MØDULE INPUT
SUBTITLE=N-SEGMENT STRING
LABEL=STATICS
LØAD=1
ØUTPUT
DISP=ALL
BEGIN BULK
SLØAD          1        3      1.0       6      1.0
ENDDATA
        7     1.0     0.0     0.0     0.0
```



2.6.1.8 N - spoked Wheel made from BAR elements (a = 8, b and c are not used)

INPUT generates N+1 GRID points, all of which are connected to the last point, and N CBAR cards. The CBAR cards represent connections around the circumference and spokes in the wheel as shown.



a. Data deck

First Card

1	N	(I8)	No. of spokes
2	XL	(E8.0)	Radius of wheel
3	IP	(I8)	Permanent constraints on rim
4	IFLG	(I8)	Orientation vector flag
5	IGO	(I8)	GO (used only if IFLG = 2)
6	ICEN	(I8)	Permanent constraints at center

Second Card

1	X1	(E8.0)	Orientation vector X1 component
2	X2	(E8.0)	Orientation vector X2 component
3	X3	(E8.0)	Orientation vector X3 component

b. Notes

(1) A PBAR card with PID = 101 is required.

(2) The option, IFLG = 2, is not allowed for this case.

(3) A coordinate system with CID = 2 is required. All points, except the center, will reference this system.

(4) The number of spokes, N, cannot exceed 255.

NASTRAN DATA DECK

```
ID INPUT, CASE 8
TIME 10
APP DISP
SØL 1,3
ALTER 1
PARAM //C,N,NØP/V,N,TRUE=-1 $
INPUT GEØM1,GEØM2,,,/G1,G2,,,/C,N,8 $
EQUIV G1,GEØM1/TRUE / G2,GEØM2/TRUE $
ENDALTER
CEND
TITLE = TEST ØF UTILITY MØDULE INPUT
SUBTITLE = N-SPØKED WHEEL
LABEL = STATICS
LØAD = 20
ØUTPUT
DISP = ALL
BEGIN BULK
CØRD2C  2       0       0.0     0.0     0.0     1.0     0.0     0.0     +CYL
+CYL    0.0     0.0     1.0
FØRCE   20      1       0       1.0     1.0     0.0     0.0
MAT1    7       1.0             0.3
PBAR    101     7       1.0     100.0   100.0
ENDDATA
       8    10.0   12456       1       0  123456
     0.0     0.0     1.0
```

Substructure Command COMBINE - Combine Sets of Substructures

Purpose: This operation will perform the operations to combine the matrices and loads up to seven substructures into matrices and loads representing a new pseudostructure. Each component structure may be translated, rotated, and reflected before it is connected. The user may manually select the points to be connected or direct the program to connect them automatically.

Request Format:

$$\text{CØMBINE}\left(\left\{\begin{matrix}\text{AUTØ}\\ \text{MAN}\end{matrix}\right\},\left\{\begin{matrix}X\\ Y\\ Z\end{matrix}\right\}\right)\ \text{name1, name2, etc.}$$

Subcommands:

NAME = new name (required)

TØLERANCE = ε (required)

CØNNECT = n

ØUTPUT = $m_1, m_2, \ldots$

Each individual component substructure may have the following added commands:

CØMPØNENT = name

TRANSFØRM = m

SYMTRANSFØRM = $\left\{\begin{matrix}X\\ Y\\ Z\\ XY\\ XZ\\ YZ\\ XYZ\end{matrix}\right\}$

SEARCH = namej, namek, etc.

(repeat for each component)

Definitions:

AUTØ/MAN - Defines method of connecting points. If AUTØ is chosen, the physical location of grid points is used to determine connections. If MAN, all connections are defined on CØNCT or CØNCT1 bulk data.

X, Y, Z - Are used on CØMBINE card for searching geometry data for AUTØ connections. Denotes preferred search direction for processing efficiency.

name1, name2, etc. - Unique names of substructures to be combined. Limits are from one to seven component structures.

new name - Defines name of combination structure (required).

ε - Defines limit of distance between points which will be automatically connected (real > 0).

n - Defines set number of manual connections and releases specified on bulk data cards, CØNCT, CØNCT1, and RELES.

name - On CØMPØNENT card defines which substructure (name1, etc.) to which the following data is applied.

m - Set identification number of TRANS and GTRAN bulk data cards which define the orientation of the substructure and/or selected grid points relative to new basic coordinates.

X,Y,...XY,...XYZ - Defines axis (or set of axes) normal to the plane(s) of symmetry in the new basic coordinate system. The displacement and location coordinates in these directions will be reversed in sign.

namej - Limits the automatic connection process such that only connections between component "name" and these structures are produced. Multiple search commands may appear for any one component (see Note 4).

m_1, m_2, etc. - Optional output requests (see Note 5).

Notes:

1. The automatic connections are produced by first sorting the grid point coordinates in the specified coordinate direction and then searching within limited groups of coordinates. If the boundary of a substructure to be connected is aligned primarily along one of the coordinate axes, this axis should be used as the preferred search direction. If the boundary is parallel with, say, the yz plane and all boundary coordinates have a constant x value, then the search should be specified along either the y or the z axis.

2. The transformation (TRANS) data defines the orientation of the component substructure (old basic) in terms of the new basic coordinate system. All grid points originally defined in the old basic system will be transformed to the new basic system. Points defined in local coordinate systems will not be transformed unless otherwise specified on a GTRAN card, and their directions will rotate with the substructure.

3. The SYMTRANFØRM (or SYMT) request is primarily used to produce symmetric reflections of a structure. This is usually preceded by an EQUIV command to produce a new, unique substructure name. Note that the results for the new reflected substructure may reference a left-handed coordinate system wherever local coordinate systems are retained during the transformation. However, those coordinates which are originally in the old basic or are newly specified via a GTRAN card are automatically transformed to a right-handed coordinate system of the combined structure during the combination process. Note that the symmetric reflection occurs first using the component's own basic coordinate system before the translational and rotational transformation called for by TRANS.

4. If any search option is present then all connections between substructures must be specified explicitly with SEARCH commands. Only those combinations specified will be searched for possible connects. Symmetric connects need not be declared (i.e., CØMPØNENT A SEARCH B implies CØMPØNENT B SEARCH A). The user is warned that care must be taken to assure all proper connections of substructures should any SEARCH commands be utilized.

5. The program automatically processes matrix data for the CØMBINE operation in the most economical order, i.e., the matrices with fewest terms are processed first.

6. The bandwidth of the resultant matrices may be controlled by selection of substructures, their boundaries, and the order in which the substructures are listed in the CØMBINE command. The degrees of freedom in the resultant matrices are located as defined in the sample problem below:

CØMBINE A, B, C, D

A	interior	ABC	boundary
AB	boundary	C	interior
B	interior	AD	boundary
AC	boundary	BD	boundary
BC	boundary	Etc.	

7. The following output requests are available for the CØMBINE operation (* marks recommended output options):

CODE	OUTPUT
2*	SØF table of contents
3	CØNCT1 bulk data summary
4	CØNCT bulk data summary
6	GTRAN bulk data summary
7*	TRANS bulk data summary
9	RELES bulk data summary
11	Summary of automatically-generated connections (in terms of internal point numbers)
12*	Complete connectivity map of final combined pseudostructure defining each internal point in terms of the grid point ID and component substructure it represents
13	The EQSS item
14	The BGSS item
15	The CSTM item
16	The PLTS item
17	The LØDS item

Output printed for codes 13–17 is formatted SØF data for the newly created pseudostructure (See Section 1.10.2 for definitions).

Examples:

1. CØMBINE PANEL SPAR

   TØLE = .0001
   NAME = SECTA

2. CØMBINE (AUTØ,Z) TANK1, TANK2, BULKHD

   NAME = TANKS
   TØLE = .01
   CØMPØNENT TANK1
   TRAN = 4
   SEARCH = BULKHD
   CØMPØNENT TANK2
   SEARCH = BULKHD

3. CØMBINE (MAN) LWING, RWING

   TØLE = 1.0
   NAME = WING
   CØMPØNENT LWING
   SYMT = Y

Substructure Command DELETE

Purpose: To delete individual substructure items from the SØF.

Request Format:

DELETE   name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

name - Substructure name

item1, item2,... - Item names (HØRG, KMTR, LØDS, SØLN, etc.)

Notes:
1. DELETE may be used to remove from one to five items of any single substructure.
2. For primary substructures, items of related secondary substructures are removed only if the later point to the same data (KMTX, MMTX, etc.).
3. For secondary and image substructures, no action is taken on items of related substructures, i.e., items of equivalenced substructures or higher or lower level substructures.
4. See the EDIT and DESTRØY commands for other means of removing substructure data.

Substructure Command DESTRØY - Removes All Data Referencing a Component Substructure

Purpose: To remove data for a substructure and all substructures of which it is a component from the SØF. In addition to the substructure being DESTRØY'ed ("name"), data for substructures which satisfy one or more of the following conditions are also removed from the SØF:

1. All substructures of which "name" is a component

2. All secondary (or equivalenced) substructures for which "name" is the primary substructure

3. All image substructures which are components of a substructure that is destroyed

Request Format:

DESTRØY   name

Subcommands: None

Definition:

name   - Name of substructure

Notes: 1. No action is taken if "name" is an image substructure.

2. See related commands EDIT and DELETE for additional means of removing substructure data.

Substructure Command DUMP

Purpose: To copy the entire SØF to an external file.

Request Format:

DUMP filename $\begin{Bmatrix} \text{DISK} \\ \underline{\text{TAPE}} \end{Bmatrix}$

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes:
1. DUMP may be used to create a backup copy of the SØF.
2. All system information on the SØF is saved.
3. The RESTØRE command will reload a DUMPed SØF.
4. DUMP/RESTØRE may not be used to change the size of the SØF.
5. It is more efficient to use operating system utility programs to create back-up copies of the SØF if they are available.

Substructure Command PLØT - Substructure Plot Command

Purpose: This operation is used to plot the undeformed shape of a substructure which may be composed of several component substructures. This command initiates the execution of a plot at any stage of the substructure process. The actual plot commands; origin data, etc., must be included in the normal case control data.

Request Format:

PLØT   name

Subcommands: None

Definitions:

name   - Name of component substructure to be plotted.

Notes: 1. The set of elements to be plotted will consist of all the elements and grid points saved in Phase 1 for each basic substructure comprising the substructures named in the PLØT command. (Only one plot set from each basic substructure is saved in Phase 1.)

2. The structure plotter output request packet, while part of the standard Case Control Deck, are treated separately in Sections 4.2 and 4.3, respectively.

Substructure Command RECØVER - Phase 2 Solution Data Recovery

Purpose: This operation recovers displacements and boundary forces on specified substructures in the Phase 2 execution. The results are saved on the SØF file and they may be printed upon user request. This command should be input after the SØLVE command to store the solution results on the SØF file.

Request Format:

RECØVER s-name

Subcommands:

SAVE - name

PRINT = name

DISP = {ALL, n, NØNE}

SPCF = {ALL, n, NØNE}

ØLØAD = {ALL, n, NØNE}

BASIC = b-name

for static analysis only:

SØRT = {SUBCASE, SUBSTRUCTURE}

SUBCASES = {ALL, n, NØNE}

for dynamic analysis only:

SØRT = {MØDES, SUBSTRUCTURE}

MØDES = {ALL, n, NØNE}

RANGE = f_1, f_2

Definitions:

s-name - Name of the substructure named in a prior SØLVE command from which the solution results are to be recovered.

name - Name of the component structure for which results are to be recovered. May be the same as "s-name".

b-name - Name of component basic substructure that following output requests are to apply to.

ALL - Output for all points will be produced.

NØNE - No output is to be produced.

n - Set identification number of a SET card appearing in Case Control. Only output for those points, subcases, or modes whose identification number appears on this SET card will be produced.

f_1, f_2 - Range of frequencies for which output will be produced. If only f_1 is present the range is assumed to be 0 - f_1.

SUBCASE - All output requests for each subcase will appear together.

MØDES - All output requests for each mode will appear together.

SUBSTRUCTURE - All output requests for each basic substructure will appear together.

Output Requests: Printed output produced by the RECØVER PRINT command can be controlled by requests present in either Case Control or the RECØVER command in the Substructure Control Deck. If no output requests are present, the PRINT command is equivalent to SAVE and no output will be printed.

The RECØVER output options described above may appear after any PRINT command. These output requests will then override any Case Control requests. The output requests for any PRINT command can also be specified for any or all basic component substructures of the results being recovered. These requests will then override any requests in Case Control or after the PRINT command.

Example of output control:

```
RECØVER SØLSTRCT
    PRINT   ABSC
        SØRT = SUBSTRUCTURE  }
        DISP = ALL           } basic defaults for ABDC output
        ØLØAD = 10           }
        BASIC   A            }
            DISP = 5         } override requests for BASIC  A
        BASIC   C            }
            ØLØAD = NØNE     } override requests for BASIC  C
            SUBCASES = 20    }
    SAVE   ABC
```

Notes: 1. SAVE will save the solution for substructure "name" on the SØF. PRINT will save and print the solution.

2. If the solution data already exists on the SØF, the existing data can be printed without costs of regeneration with the PRINT command.

3. For efficiency, the user should order multiple SAVE and/or PRINT commands so as to trace one branch at a time starting from his solution structure.

4. Reaction forces are computed for a substructure only if (1) the substructure is named on a PRINT subcommand and, (2) an output request for SPCFØRCE exists in the Case Control or the RECØVER command.

5. All set definitions should appear in Case Control to ensure their availability to the RECØVER module.

6. The SØRT output option should only appear after a PRINT command. Any SØRT commands appearing after a BASIC command will be ignored.

7. If both a MODES request and a RANGE request appear for dynamic analysis, both requests must be satisfied for any output to be produced.

8. The media, print or punch, where output is produced is controlled through Case Control requests. If no Case Control requests are present, the default of print is used.

Substructure Command REDUCE - Phase 2 Reduction to Retained Degrees of Freedom

Purpose: This operation performs a Guyan matrix reduction process for a specified component substructure, otherwise known as matrix condensation. It produces the same result as obtained by the specification of NASTRAN ØMIT or ASET data. The purpose is to reduce the size of the matrices. In static analysis only points on the boundary need be retained. In dynamics, the boundary points and selected interior points are retained.

Request Format:

REDUCE name

Subcommands:

NAME - new name

BØUNDARY - n

ØUTPUT - m_1, m_2,...

RSAVE

Definitions:

name - Name of substructure to be reduced.

new name - Name of resulting substructure.

n - Set identification number of BDYC bulk data cards which define sets of retained degrees of freedom for the resulting reduced substructure matrices.

m_1, m_2, etc. - Optional output requests (see Note 3).

Notes:
1. All references to the grid points and components not defined in the "boundary set" will be reduced out of the new substructure. Any subsequent reference to these omitted degrees of freedom in CØMBINE, REDUCE, or SØLVE operations generates an error condition.

2. The same transformations will be applied to the reduced mass matrix for the new substructure. See the NASTRAN Theoretical Manual for a discussion of this effect.

3. The following output requests are available for the REDUCE operation (* marks recommended output options):

CODE	OUTPUT	
1*	Current problem summary	
2	Boundary set summary	
3	Summary of grid point ID numbers in each boundary set	
4	The EQSS item for the structure being reduced	
5*	The EQSS item	These requests write formatted SØF items for the new reduced pseudostructure
6*	The BGSS item	
7	The CSTM item	
8	The PLTS item	
9*	The LØDS item	

4. If the RSAVE card is included, the decomposition product of the interior point stiffness matrix (LMTX item) is saved on the SØF file. This matrix will be used in the data recovery for the omitted points. If it is not saved it will be regenerated when needed.

Substructure Command RESTØRE

Purpose: To reload the SØF from an external file created with the DUMP command.

Request Format:

RESTØRE filename $\left\{ \begin{array}{l} \text{DISK} \\ \underline{\text{TAPE}} \end{array} \right\}$

Subcommands: None

Definitions:

Filename - Name of the external file. Any one of the following: INPT, INP1,..., INP9.

DISK - File resides on a direct access device.

TAPE - File resides on tape.

Notes:

1. The external file must have been created with the DUMP command.
2. The SØF must be declared as 'NEW' on the SØF command.
3. RESTØRE must be the very first substructure command following the SØF and PASSWØRD declarations.
4. The SØF size declarations for the RESTØRE command must be exactly the same as for the SØF which was DUMPed. The DUMP/RESTØRE commands can not be used to increase the size of the SØF.

Substructure Mode Control RUN - Specifies Run Options

Purpose: This command is used to limit the substructure execution for the purpose of checking the validity of the input data. It allows for the processing of input data separately from the actual execution of the matrix operations.

Request Format:

$$\text{RUN} \left\{ \begin{array}{c} \text{DRY} \\ \text{G}\emptyset \\ \text{DRYG}\emptyset \\ \underline{\text{STEP}} \end{array} \right\}$$

Subcommands: None

Definitions:

DRY - Limits the execution to table and transformation matrix generation. Matrix operations are skipped.

GØ - Limits the execution to matrix generation only. This mode must have been preceded by a successful RUN=DRY execution. Also, this mode may be used with new ØPTIONS following a successful RUN=STEP execution.

DRYGØ - Will cause execution of a complete dry run for the entire job, followed by a RUN=GØ execution if no fatal errors were detected.

STEP - Will cause the execution of both DRY and GØ operations one step at a time.

Notes:
1. The DRY, GØ and STEP options may be changed at any step in the input substructure command sequence. If the DRYGØ option is used, the RUN card must appear only once at the beginning.
2. If a fatal error occurs during the first pass of the DRYGØ option, the program exits at the completion of all DRY operations.

Substructure Operation File Declaration SØF - Assigns Physical Files for Storage of the SØF

Purpose: This declaration defines the names and sizes of the physical NASTRAN files the user assigns for storage of the SØF file. At least one of these declarations must be present in each substructure command deck. As many SØF declarations are required in the substructure command deck on each run as there are physical files assigned for the storage of the SØF file.

Request Format:

SØF(no.) = filename, filesize, $\left\{ \begin{array}{c} \text{ØLD} \\ \text{NEW} \end{array} \right\}$

Subcommands:

PASSWØRD = password

Definitions:

no. - Integer index of SØF file (1, 2, etc.) in ascending order of files required for storage of the SØF. The maximum index is 10.

filename - User name for an SØF physical file.

filesize - Size of allocated file space in kilowords, default = 100.

ØLD - SØF data is assumed to already exist on the file.

NEW - The SØF is new. In this case, the SØF will be initialized.

password - BCD password for the SØF (8 characters maximum) used to protect the file and insure that the correct file is assigned for the current run (see the PASSWØRD card description).

Notes:

1. If more space is required for storage of the SØF file, additional physical files may be declared. Alternately, the file size parameter on a previously declared file may be increased, but only on the last physical file if more than one is used (on IBM the size of an existing file may not be increased.

2. Once an SØF declaration is made, the index of the SØF file must always be associated with the same file name. File names may not be changed from run to run.

3. The file names of each physical SØF file must be unique.

4. The declared size of the SØF may be reduced by the amount of contiguous free-space at the end of the logical SØF file. This may be accomplished by removing the physical file declaration for those unused files which have the highest sequence numbers. An attempt to eliminate a portion of the SØF which contains valid data will result in a fatal error.

5. If the NEW parameter is present on any one of the SØF declarations, the entire logical SØF is considered new. Therefore, if an additional physical file is added to an existing SØF, the NEW parameter should not be included on any declarations.

6. The following conventions should be used for the file name declarations on each of the three NASTRAN computers:

CDC/CYBER

Must be a 4-character alphanumeric name with no special characters or blanks allowed. The file name used on the SØF declaration must correspond to ones used on the system REQUEST or ATTACH card. Note that after a NASTRAN execution, the SØF files should be catalogued or extended.

Examples:

1. Create a new SØF file with a filename of SØF1 and catalogue it.

```
REQUEST(SØF1,*PF)
NASTRAN.
CATALØG(SØF1,username)
789
.
.
.
NASTRAN data cards including the SØF declaration --
SØF(1)=SØF1,1000,NEW
.
.
.
6789
```

2. Use of an existing SØF file with a filename of ABCD.

```
ATTACH(ABCD,username)
NASTRAN.
EXTEND(ABCD)
789
.
.
.
NASTRAN data cards including the SØF declaration --
SØF(1)=ABCD,1000
.
.
.
6789
```

UNIVAC 1108/1110

The filename used on the SØF declaration must specify one of the NASTRAN user files INPT, INP1,..., INP9.

Examples:

1. Create a new SØF file named INPT.

```
@ASG,U INPT.,F///1000
@HDG,N
@XQT *NASTRAN.LINK1
.
NASTRAN FILES=INPT
.
NASTRAN data cards including the SØF declaration --
SØF(1)=INPT,400,NEW
.
.
.
@FIN
```

2. Use of an existing SØF file with a filename of INP7.

```
@ASG,AX INP7.
@HDG,N
@XQT  *NASTRAN.LINK1
.
NASTRAN FILES=INP7
.
NASTRAN data cards including the SØF declaration --
SØF(1)=INP7,250
.
.
.
@FIN
```

IBM 360/370

The file name used on the SØF declaration must specify a FØRTRAN unit by using the form FTxx from the table of allowable file names shown below which correspond to the direct access devices that are supported under the SØF implementation. The allocation of space for the direct access FØRTRAN data sets can be made in terms of blocks, tracks or cylinder. If the allocation is in blocks, the block size in the space allocation corresponds to (BUFFSIZE-4)*4 bytes where BUFFSIZE is the GINØ buffer size found in SYSTEM(1).

In order to use the SØF on IBM computers, it is necessary to specify the PARM on the EXEC PGM=NASTRAN card. This PARM sets the amount of core (in bytes) NASTRAN releases to the operating system for system use and FØRTRAN buffers. The following formula should be used to determine the value for the PARM:

```
PARM =  (4096 + m*((BUFFSIZE-4) + 64))*4 single buffering, BUFNØ=1
        (4096 + m*(2*(BUFFSIZE-4) + 96))*4 double buffering, BUFNØ=2
```

where m = number of physical datasets comprising the SØF.

Examples:

1. Create a new SØF data set with a filename of FT11.

```
//NSGØ EXEC NASTRAN,PARM.NS='CØRE=(,60K)'
//NS.FT11F001 DD DSN = User Name, UNIT=2314, VØL=SER=User No..
//   DISP=(NEW,KEEP), SPACE=TRK,(1000)), DCB=BUFNØ=1
//NS.SYSIN DD *
NASTRAN BUFFSIZE=1826
.
.
.
NASTRAN data cards including the SØF delcaration --

SØF(1)=FT11,,NEW
.
.
.
/*
```

Notes:

1. The SØF parameters - filename, filesize, and (ØLD/NEW) are positional parameters. The filesize parameter is not required for IBM 360/370 computers, but its position must be noted if NEW is coded for the SØF filc.

2. The dataset disposition must be DISP=(NEW,KEEP) when the SØF dataset is created. However, an existing SØF dataset may be re-initialized by coding NEW on the SØF declaration in the NASTRAN data deck. In this case, the sipoisition on the DD card must be coded DISP=ØLD.

2. Use of an existing SØF dataset with a filename of FT23.

```
//NS EXEC NASTRAN,PARM.NS='CORE=(,72K)'
//NS.FT23F001 DD DSN = User Name, UNIT=3330, VØL=SER=User No.,
// DCB=BUFNØ=1, DISP=ØLD
//NS.SYSIN DD *
NASTRAN BUFFSIZE=3260
SØF (1)=FT23
.
.
.
/*
```

SUBSTRUCTURE CONTROL DECK

SØF File Name	FØRTRAN Unit DDName	SØF File Name	FØRTRAN Unit DDName
FT02	FT02F001	FT16	FT16F001
FT03	FT03F001	FT17	FT17F001
FT08	FT08F001	FT18	FT18F001
FT09	FT09F001	FT19	FT19F001
FT10	FT10F001	FT20	FT20F001
FT11	FT11F001	FT21	FT21F001
FT12	FT12F001	FT22	FT22F001
FT15	FT15F001	FT23	FT23F001

Note: A maximum of 10 SØF file names is allowed in any NASTRAN substructuring run.

Substructure Command <u>SØFIN</u>

Purpose: To copy substructure items from an external file to the SØF.

Request Format:

SØFIN $\left(\begin{Bmatrix}\text{EXTERNAL}\\ \underline{\text{INTERNAL}}\end{Bmatrix}\right)$ filename $\begin{Bmatrix}\text{,DISK}\\ \underline{\text{,TAPE}}\end{Bmatrix}$

Subcommands:

POSITION = $\begin{Bmatrix}\text{REWIND}\\ \underline{\text{NØREWIND}}\end{Bmatrix}$

NAMES = $\begin{Bmatrix}\text{substructure name}\\ \underline{\text{WHØLESØF}}\end{Bmatrix}$

ITEMS = $\begin{Bmatrix}\text{ALL}\\ \text{MATRICES}\\ \text{PHASE3}\\ \text{TABLES}\\ \text{item name}\end{Bmatrix}$

Definitions:

EXTERNAL - File was written on a different computer type.

INTERNAL - File was written with GINØ on the same computer type.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITION - Specifies initial file position.

REWIND: file is rewound
NØREWIND: input begins at the current position

NAMES - Identifies a substructure for which data will be read. If NAMES=WHØLESØF is coded, and no other NAMES subcommands appear for the current SØFIN command, all substructure items found on the external file from the point specified by the PØSITIØN subcommand to the end-of-file are copied to the SØF.

ITEMS - Identifies the data items which are to be copied to the SØF for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item name: name of an individual item

Notes: 1. Filename is required. The other SØFIN operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFIN command.

4. If a substructure name of an item which is to be copied to the SØF does not exist on the SØF, it is added to the SØF. MDI pointers for higher level, combined substructures and lower level substructures are restored.

5. For the EXTERNAL form of this command all the items on the file are read in and added to the SØF. The PØSITIØN subcommand should be specified as REWIND and user specifications for all other subcommands are ignored.

6. SØFØUT is the companion substructure command.

7. When an internal-formated file is located on tape and extends over multiple reels, care should be taken when using the SØFIN command. The commands should be ordered so that all the desired data is retrieved on a single pass through the tape. The following suggestions are helpful:

   a. Order the SØFIN command to obtain data in the order they exist on the tape. If this order is not known, the CHECK command will list the contents of the tape.

   b. The first SØFIN command should specify PØSITIØN=REWIND and all subsequent commands should use PØSITIØN=NØREWIND.

   c. The individual items should be requested by name. The ALL, MATRICES, TABLES or PHASE3 specification should not be used for the ITEMS subcommand unless all the appropriate items are on the tape. If some are not present, the tape will be searched to the end of the last reel and subsequent commands will not be executable because they will attempt to rewind back to the first tape.

8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//    LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//    TRTCH=T,DEN=2)
```

Substructure Command SØFØUT

Purpose: To copy substructure items from the SØF to an external file.

Request Format:

SØFØUT $\left(\left\{\begin{matrix}\text{EXTERNAL}\\ \underline{\text{INTERNAL}}\end{matrix}\right\}\right)$ filename $\left\{\begin{matrix}\text{,DISK}\\ \underline{\text{TAPE}}\end{matrix}\right\}$

Subcommands:

PØSITIØN = $\left\{\begin{matrix}\text{REWIND}\\ \underline{\text{NØREWIND}}\\ \text{EØF}\end{matrix}\right\}$

NAMES = $\left\{\begin{matrix}\text{substructure name}\\ \underline{\text{WHØLESØF}}\end{matrix}\right\}$

ITEMS = $\left\{\begin{matrix}\underline{\text{ALL}}\\ \text{MATRICES}\\ \text{PHASE3}\\ \text{TABLES}\\ \text{item name}\end{matrix}\right\}$

Definitions:

EXTERNAL - File will be written so that it may be read on a different computer type.

INTERNAL - File will be written with GINØ.

Filename - Name of the external file. If the file is in INTERNAL format, filename must specify INPT, INP1,...,INP9. If the file is in EXTERNAL format, filename must specify a FØRTRAN unit by using the form FØRT1, FØRT2,...,FØRT32.

DISK - File is located on a direct access device.

TAPE - File is located on a tape.

PØSITIØN - Specifies initial file position. (See Note 6)

REWIND: file is rewound
NØREWIND: output begins at the current position
EØF: file is positioned to the point immediately preceding the end-of-file mark.

NAMES - Identifies a substructure for which data will be written. If NAMES=WHØLESØF is coded and no other NAMES subcommands appear for the current SØFØUT command, all substructure items found on the SØF are copied to the external file.

ITEMS - Identifies the data items which are to be copied to the external file for each substructure specified by the NAMES subcommands.

ALL: all items
MATRICES: all matrix items
PHASE3: the UVEC, QVEC, and SØLN items
TABLES: all table items
item names: name of an individual item

Notes: 1. Filename is required. The other SØFØUT operands are optional.

2. All subcommands are optional.

3. The NAMES subcommand may appear up to five times for each SØFØUT command.

4. PLTS items of pseudostructures reference the PLTS items of the component basic substructures. Therefore, in order to save all data necessary to plot a pseudostructure, the PLTS items of its component basic substructures must be saved as well as the PLTS item of the pseudostructure.

5. For the external form of this command, PØSITIØN=NØREWIND has the effect of positioning the file to the end-of-file.

6. PØSITIØN=REWIND should be coded for the first write to a new file.

7. SØFIN is the companion substructure command.

8. On IBM computers and for the EXTERNAL form of this command, the following DD card should be used:

```
//NS.FTxxF001 DD DSN=username,UNIT=2400-1,DISP=(,KEEP),
//     LABEL=(,NL),DCB=(RECFM=FB,LRECL=132,BLKSIZE=3960,
//     TRTCH=T,DEN=2)
```

Substructure Command SØFPRINT

Purpose: To print selected contents of the SØF file for data checking purposes.

Request Format:

SØFPRINT(opt) name, item1, item2, item3, item4, item5

Subcommands: None

Definitions:

opt - integer, control option, default = 0.

opt = 1: prints data only (matrix elements or table entries)
opt = 0: prints table of contents only (list of substructures on SØF)
opt = -1: prints both

name - Name of substructure for which data is to be printed.

itemj - SØF item name, used only when opt ≠ 0. No more than five items from Table 2, Section 1.4 may be requested per command.

Notes: 1. If only the table of contents is desired (opt = 0), this command may be coded:

SØFPRINT TØC

On the page heading for the table of contents, the labels are defined as follows:

IS - Image substructure flag. 0 - not an image substructure
1 - image substructure

SS - Secondary substructure number (successor)

PS - Primary substructure number (predecessor)

LL - Lower level substructure number

CS - Combined substructure number

HL - Higher level substructure number

2. The table of contents is followed by two lines of information showing the amount of unused space on the SØF (in words) and the highest block used.

Substructure Command SØLVE - Substructure Solution

Purpose: This command initiates the substructure solution phase. The tables and matrices for the pseudostructure are converted to their equivalent NASTRAN data blocks. The substructure grid points referenced on bulk data cards SPCS, MPC, etc., are converted to pseudostructure scalar point identification numbers. The NASTRAN execution then proceeds as though a normal structure were being processed.

Request Format:

SØLVE   name

Subcommands: None (Case Control and Bulk Data decks control the operations.)

Definition:

name - Name of pseudostructure to be analyzed with NASTRAN.

Notes: 1. Before requesting a SØLVE, the user should check to be sure that all necessary matrices are available on the SØF file. For instance, loads and stiffness matrices are necessary in statics analysis. Mass and stiffness matrices are necessary in eigenvalue analysis, etc.

2. If the ØPTIØNS command has been used, an additional ØPTIØNS command may be necessary to ensure that the matrices required are available for the SØLVE operation.

3. The SØLVE command should always be followed by RECØVER to assure the solution data are saved on the SØF.

SUBSTRUCTURE CONTROL DECK

Substructure Command SUBSTRUCTURE - Initiates the Substructure Control Data Deck

Purpose: This command initiates the processing for automated substructuring and defines the phase of the analysis. It must be the first card in the Substructure Control Deck.

Request Format:

$$\text{SUBSTRUCTURE} \left\{ \begin{array}{l} \text{PHASE1} \\ \text{PHASE2} \\ \text{PHASE3} \end{array} \right\}$$

Subcommands:

NAME = name (required for PHASE1 and PHASE3)

SAVEPLØT = n (used only in PHASE1)

Definitions:

name - The name assigned to the basic substructure which is being created in PHASE1 or for which results are to be computed in PHASE3.

n - The plot set identification used to define the set of elements and grid points to be saved in PHASE1 for subsequent plotting in PHASE2. Only one set may be defined for any basic substructure.

Notes:

1. The mode command RUN=STEP is assumed initially if the explicit command is not given immediately following the SUBSTRUCTURE command.

2. No further substructure commands are required for PHASE1.

3. Additional substructure commands are required for PHASE2.

4. For PHASE3 operations, RECØVER and BRECØVER are equivalent commands and one of them must be present.

5. Imbedded blanks within the individual elements of this card are not allowed. An unrecognizable command causes the program to automatically assume a PHASE2 solution.

3. RIGID FORMATS

3.1 GENERAL DESCRIPTION OF RIGID FORMATS

The most general way of using NASTRAN is with a user written Direct Matrix Abstraction Program (DMAP). This procedure permits the user to execute a series of matrix operations of his choice along with any utility modules or executive operations that he may need. The user may even choose to write a module of his own. The rules governing all of these operations are described in Section 5.

In order to relieve the user from the necessity of constructing a DMAP sequence for each of his problems, a number of such sequences have been included in NASTRAN as rigid formats. A rigid format consists of two parts. The first part is a DMAP sequence that is stored in NASTRAN and available to the user by specifying the number of the rigid format on the SØL card in the Executive Control Deck. The second part of a rigid format is a set of restart tables that automatically modify the series of DMAP operations to account for any changes that are made in any part of the Data Deck when making a restart, after having previously run all, or a part of the problem. Without such tables, the user would have to carefully modify his DMAP sequence to account for the conditions surrounding each restart. The chances for error in making these modifications for restart are very great. The restart tables not only relieve the user of the burden of modifying his DMAP sequence, but also assures him of a correct and efficient program execution.

In addition to the DMAP sequence provided with each rigid format, a number of options are available, which are subsets of each complete DMAP sequence. Subsets are selected by specifying the subset numbers (zero for the complete DMAP sequence) along with the rigid format number on the SØL card in the Executive Control Deck. See Section 2.2.1 for list of available subsets.

If the user wishes to modify the DMAP sequence of a rigid format in some manner not provided for in the available subsets, he can use the ALTER feature described in Section 2. Typical uses are to schedule an EXIT prior to completion, in order to check intermediate output, schedule the printing of a table or matrix for diagnostic purposes, and to delete, or add a functional module to the DMAP sequence. Any DMAP instructions that are added to a rigid format are automatically executed when a restart is performed. The user should be familiar with the rules for DMAP programming, as described in Section 5, prior to making alterations to a rigid format.

RIGID FORMATS

The following rigid formats for structural analysis are currently included in NASTRAN:

1. Static Analysis
2. Static Analysis with Inertia Relief
3. Normal Mode Analysis
4. Static Analysis with Differential Stiffness
5. Buckling Analysis
6. Piecewise Linear Analysis
7. Direct Complex Eigenvalue Analysis
8. Direct Frequency and Random Response
9. Direct Transient Response
10. Modal Complex Eigenvalue Analysis
11. Modal Frequency and Random Response
12. Modal Transient Response
13. Normal Modes Analysis with Differential Stiffness
14. Static Analysis with Cyclic Symmetry
15. Normal Modes Analysis with Cyclic Symmetry

The following rigid formats for heat transfer analysis are included in NASTRAN:

1. Linear Static Heat Transfer Analysis
3. Nonlinear Static Heat Transfer Analysis
9. Transient Heat Transfer Analysis

The following rigid formats for aeroelastic analysis are included in NASTRAN:

10. Modal Flutter Analysis
11. Modal Aeroelastic Response

3.1.1 Input File Processor

The Input File Processor operates in the Preface prior to the execution of the DMAP operations in the rigid format. A complete description of the operations in the Preface is given in the Programmer's Manual. The main interest here is to indicate the source of data blocks that are created in the Preface and hence appear only as inputs in the DMAP sequences of the rigid formats. None of the data blocks created by the Input File Processor are checkpointed, as they are always regenerated on restart. The Input File Processor is divided into five parts. The first part (IFP1) processes the Case Control Deck, the second part (IFP) processes the Bulk Data

3.2 STATIC ANALYSIS

3.2.1 DMAP Sequence for Static Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.1 STATIC ANALYSIS - SERIES 0 $

    2  FILE     OPTP2=SAVE/EST1=SAVE $

    3  FILE     QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE $

    4  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT/V,N,ALWAYS=-1 $

    5  SAVE     LUSET $

    6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    7  GP2      GEOM2,EQEXIN/ECT $

    8  CHKPNT   ECT $

    9  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   10  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   11  COND     P1,NOPCDB $

   12  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   13  SAVE     NSIL,JUMPPLOT $

   14  PRTMSG   PLTSETX// $

   15  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   16  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   17  COND     P1,JUMPPLOT $

   18  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V.N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $


   19  SAVE     JUMPPLOT,PLTFLG,PFILE $

   20  PRTMSG   PLOTX1// $

   21  LABEL    P1 $

   22  CHKPNT   PLTPAR,GPSETS,ELSETS $

   23  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV/V,N,NEVER=1 $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  SAVE     NOGRAV $
25  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $
26  CHKPNT   SLT,GPTT $
27  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
28  SAVE     NOSIMP,NOGENL,GENEL $
29  PARAM    //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $
30  COND     ERROR4,NOELMT $
31  PURGE    KGGX,GPST/NOSIMP/OGPST/GENEL $
32  CHKPNT   EST,GPECT,GEI,GPST,OGPST $
33  OPTPR1   MPT,EPT,ECT,DIT,EST/OPTP1/V,N,PRINT/V,N,TSTART/V,N,COUNT $
34  SAVE     PRINT,TSTART,COUNT $
35  CHKPNT   OPTP1 $
36  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
37  JUMP     LOOPTOP $
---------------------------------------------------- Top of Optimization Loop
38  LABEL    LOOPTOP $
39  COND     LBL1,NOSIMP $
40  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
41  EQUIV    OPTP1,OPTP2/NEVER/EST,EST1/NEVER $
42  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,

             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
43  SAVE     NOKGGX,NOMGG $
44  CHKPNT   KELM,KDICT,MELM,MDICT $
45  COND     JMPKGG,NOKGGX $
46  EMA      GPECT,KDICT,KELM/KGGX,GPST $
47  CHKPNT   KGGX,GPST $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  LABEL    JMPKGG $

49  COND     JMPMGG,NOMGG $

50  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

51  CHKPNT   MGG $

52  LABEL    JMPMGG $

53  COND     LBL1,GRDPNT $

54  COND     ERROR2,NOMGG $

55  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

56  OFP      OGPWG,,,,,// $

57  LABEL    LBL1 $

58  EQUIV    KGGX,KGG/NOGENL $

59  CHKPNT   KGG $

60  COND     LBL11A,NOGENL $

61  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

62  CHKPNT   KGG $

63  LABEL    LBL11A $

64  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

65  JUMP     LBL11 $
------------------------------------------------------ Top of DMAP Loop
66  LABEL    LBL11 $

67  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,

             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

68  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

69  COND     ERROR3,NOL $

70  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

71  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
             KFS,KSS/SINGLE/QG/NOSR $

72  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG,
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                YS,ASET $
73  COND        LBL4,GENEL $
74  GPSP        GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
75  SAVE        NOGPST $
76  COND        LBL4,NOGPST $
77  OFP         OGPST,,,,,// $
78  LABEL       LBL4 $
79  EQUIV       KGG,KNN/MPCF1 $
80  CHKPNT      KNN $
81  COND        LBL2,MPCF2 $
82  MCE1        USET,RG/GM $
83  CHKPNT      GM $
84  MCE2        USET,GM,KGG,,,/KNN,,, $
85  CHKPNT      KNN $
86  LABEL       LBL2 $
87  EQUIV       KNN,KFF/SINGLE $
88  CHKPNT      KFF $
89  COND        LBL3,SINGLE $
90  SCE1        USET,KNN,,,/KFF,KFS,KSS,,, $
91  CHKPNT      KFS,KSS,KFF $
92  LABEL       LBL3 $

93  EQUIV       KFF,KAA/OMIT $
94  CHKPNT      KAA $
95  COND        LBL5,OMIT $
96  SMP1        USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
97  CHKPNT      GO,KAA,KOO,LOO $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  LABEL    LBL5 $
 99  EQUIV    KAA,KLL/REACT $
100  CHKPNT   KLL $
101  COND     LBL6,REACT $
102  RBMG1    USET,KAA,/KLL,KLR,KRR,,, $
103  CHKPNT   KLL,KLR,KRR $
104  LABEL    LBL6 $
105  RBMG2    KLL/LLL $
106  CHKPNT   LLL $
107  COND     LBL7,REACT $
108  RBMG3    LLL,KLR,KRR/DM $
109  CHKPNT   DM $
110  LABEL    LBL7 $
111  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $
112  CHKPNT   PG $
113  EQUIV    PG,PL/NOSET $
114  CHKPNT   PL $
115  COND     LBL10,NOSET $
116  SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
117  CHKPNT   QR,PO,PS,PL $

118  LABEL    LBL10 $
119  SSG3     LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              V,N,NSKIP/V,N,EPSI $
120  SAVE     EPSI $
121  CHKPNT   ULV,UOOV,RULV,RUOV $
122  COND     LBL9,IRES $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  MATGPR   GPL,USET,SIL,RULV//C,N,L $

124  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

125  LABEL    LBL9 $

126  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
              C,N,STATICS $

127  CHKPNT   UGV,PGG,QG $

128  COND     LBL8,REPEAT $

129  REPT     LBL11,360 $
--------------------------------------------------- Bottom of DMAP Loop
130  JUMP     ERROR1 $

131  PARAM    //C,N,NOT/V,N,TEST/V,N,REPEAT $

132  COND     ERROR5,TEST $

133  LABEL    LBL8 $

134  CHKPNT   CSTM $

135  GPFDR    CASECC,UGV,KELM,KDICT,ECT,EQEXIN,GPECT,PGG,QG/ONRGY1,OGPFB1/
              C,N,STATICS $

136  OFP      ONRGY1,OGPFB1,,,,// $

137  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,
              XYCDB,PGG/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS/V,N,
              NOSORT2=-1 $

138  SAVE     NOSORT2 $

139  COND     LBL17,NOSORT2 $

140  SDR3     OUGV1,OPG1,OQG1,OEF1,OES1,/OUGV2,OPG2,OQG2,OEF2,OES2, $


141  OFP      OUGV2,OPG2,OQG2,OEF2,OES2,//V,N,CARDNO $

142  SAVE     CARDNO $

143  XYTRAN   XYCDB,OPG2,OQG2,OUGV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $

144  SAVE     PFILE,CARDNO $

145  XYPLOT   XYPLTT// $

146  JUMP     DPLOT $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
147  LABEL    LBL17 $

148  COND     LBLOFP,COUNT $

149  OPTPR2   OPTP1,OES1,EST/OPTP2,EST1/V,N,PRINT/V,N,TSTART/V,N,COUNT/V,N,
              CARDNO $

150  SAVE     CARDNO,COUNT,PRINT $

151  EQUIV    EST1,EST/ALWAYS/OPTP2,OPTP1/ALWAYS $

152  COND     LOOPEND,PRINT $

153  LABEL    LBLOFP $

154  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

155  SAVE     CARDNO $

156  COND     P2,JUMPPLOT $

157  LABEL    OPLOT $

158  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

159  SAVE     PFILE $

160  PRTMSG   PLOTX2// $

161  LABEL    P2 $

162  LABEL    LOOPEND $

163  COND     FINIS,COUNT $

164  REPT     LOOPTOP,360 $
                                              Bottom of Optimization Loop
165  JUMP     FINIS $


166  LABEL    ERROR1 $

167  PRTPARM  //C,N,-1/C,N,STATICS $

168  LABEL    ERROR2 $

169  PRTPARM  //C,N,-2/C,N,STATICS $

170  LABEL    ERROR3 $

171  PRTPARM  //C,N,-3/C,N,STATICS $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
172  LABEL     ERROR4 $
173  PRTPARM   //C,N,-4/C,N,STATICS $
174  LABEL     ERROR5 $
175  PRTPARM   //C,N,-5/C,N,STATICS $
176  LABEL     FINIS $
177  END       $
```

3.2.2 Description of DMAP Operations for Static Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

7. GP2 generates Element Connection Table with internal indices.

11. Go to DMAP No. 21 if no plot output is requested.

12. PLTSET transforms user input into a form used to drive structure plotter.

14. PRTMSG prints error messages associated with structure plotter.

17. Go to DMAP No. 21 if no undeformed structure plots are requested.

18. PLØT generates all requested undeformed structure plots.

20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

23. GP3 generates Static Loads Table and Grid Point Temperature Table.

27. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 172 and print error message if no elements have been defined.

33. ØPTPR1 performs phase one property optimization and initialization check.

37. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

38. Beginning of Loop for property optimization.

39. Go to DMAP No. 57 if there are no structural elements.

42. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

45. Go to DMAP No. 48 if no stiffness matrix is to be assembled.

46. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

49. Go to DMAP No. 52 if no mass matrix is to be assembled.

50. EMA assembles mass matrix $[M_{gg}]$.

53. Go to DMAP No. 57 if no weight and balance is requested.

54. Go to DMAP No. 168 and print error message if no mass matrix exists.

55. GPWG generates weight and balance information.

56. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

58. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

60. Go to DMAP No. 63 if no general elements.

61. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

65. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

66. Beginning of Loop for additional constraint sets

67. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

69. Go to DMAP No. 170 and print error message if no independent degrees of freedom are defined.

73. Go to DMAP No. 78 if general elements present.

74. GPSP determines if possible grid point singularities remain.

76. Go to DMAP No. 78 if no grid point singularities remain.

77. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

79. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

81. Go to DMAP No. 86 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

82. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

84. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

87. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

89. Go to DMAP No. 92 if no single-point constraints.

90. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

93. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Go to DMAP No. 98 if no omitted coordinates.

96. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

99. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

101. Go to DMAP No. 104 if no free-body supports.

102. RBMG1 partitions out-free body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

105. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

107. Go to DMAP No. 110 if no free-body supports.

108. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

111. SSG1 generates static load vectors $\{P_g\}$.

113. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

116. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

119. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} \ ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} \ ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} \ ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} \ ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}}$$

122. Go to DMAP No. 125 if residual vectors are not to be printed.

123. MATGPR prints the residual vector for independent coordinates (RULV)

124. MATGPR prints the residual vector for omitted coordinates (RUØV).

126. SDR1 recovers dependent displacements

$$\left\{\begin{array}{c} u_\ell \\ \hline u_r \end{array}\right\} = \{u_a\} \ , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \ ,$$

$$\left\{\begin{array}{c} u_a \\ \hline u_o \end{array}\right\} = \{u_f\} \ , \qquad \left\{\begin{array}{c} u_f \\ \hline Y_s \end{array}\right\} = \{u_n\} \ ,$$

$$\{u_m\} = [G_m]\{u_n\} \ , \qquad \left\{\begin{array}{c} u_n \\ \hline u_m \end{array}\right\} = \{u_g\} \ ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\}.$$

128. Go to DMAP No. 133 if all constraint sets have been processed.

129. Go to DMAP No. 66 if additional sets of constraints need to be processed.

130. Go to DMAP No. 166 and print error message if number of loops exceeds 360.

132. Go to DMAP No. 174 and print error message if multiple boundary conditions are attempted with improper subset.

135. GPFDR calculates the grid point force balance (ØGPFB1) and element strain energy (ØNRGY1) for requested sets.

136. ØFP formats tables prepared by GPFDR and places them on the system output file for printing.

137. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

139. Go to DMAP No. 147 if no output requests for grid point number or element number sort.

140. SDR3 prepares requested output sorted by grid point number of element number.

141. ØFP formats tables prepared by SDR3 for output sorted by grid point number or element number and places it on the system output file for printing.

143. XYTRAN prepares the input for requested X-Y plots.

145. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. subcase.

146. Go to DMAP No. 157 because printed output is not requested by subcase number.

148. Go to DMAP No. 153 if no phase two property optimization.

149. ØPTPR2 performs phase two property optimization.

151. Equivalence EST1 to EST and ØPTP2 to ØPTP1 everytime this instruction is executed.

152. Go to DMAP No. 162 if no additional output is to be printed for this loop.

154. ØFP formats tables prepared by SDR2 for output sorted by subcase number and places them on the system output file for printing.

156. Go to DMAP No. 161 if no deformed structure plots are requested.

158. PLØT generates all requested deformed structure and contour plots.

160. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

163. Go to DMAP No. 176 and make a normal exit if property optimization is complete.

164. Go to DMAP No. 38 if additional loops for property optimization are needed.

165. Go to DMAP No. 176 and make normal exit.

167. STATIC ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

169. STATIC ANALYSIS ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

171. STATIC ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

173. STATIC ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

175. STATIC ANALYSIS ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.2.3 Case Control Deck and Parameters for Static Analysis

The following items relate to subcase definition and data selection for Static Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.
2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection unless all loading is specified with grid point displacements on SPC cards.
3. An SPC set must be selected for (not necessarily within) each subcase, unless the model is a properly supported free body, or all constraints are specified on GRID cards, Scalar Connection cards, or with General Elements.
4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.
5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following printed output, sorted by loads (SØRT1) or by grid point number or element number (SØRT2), may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.
2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model.
2. Contour plots of stress and displacement.
3. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point versus subcase.
4. X-Y plot of any stress or force component for an element versus subcase.

The following parameters are used in Static Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. COUPMASS - CPBAR, CPROD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices, rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.2.4 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Static Analysis, Rigid Format 1, are altered for automatic substructure analyses.

Phase 1: 69, 100-110, 115-161

Phase 2: 4-5, 9-22, 29-30, 41, 58-61, 73-78, 134-164

Phase 3: 100-110, 115-125, 127

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.3 STATIC ANALYSIS WITH INERTIA RELIEF

3.3.1 DMAP Sequence for Static Analysis with Inertia Relief

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.2 STATIC ANALYSIS WITH INERTIA RELIEF - SERIES O $

    2  FILE     QG=APPEND/PGG=APPEND/UGV=APPEND/GM=SAVE/KNN=SAVE/MNN=SAVE $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  CHKPNT   SLT,GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 2

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
              NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE      NOSIMP,NOGENL,GENEL $

26  COND      ERROR1,NOSIMP $

27  PURGE     OGPST/GENEL $

28  CHKPNT    EST,GPECT,GEI,OGPST $

29  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM     //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG       EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
              N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
              CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
              CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE      NOKGGX,NOMGG $

33  CHKPNT    KELM,KDICT,MELM,MDICT $

34  COND      JMPKGG,NOKGGX $

35  EMA       GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT    KGGX,GPST $

37  LABEL     JMPKGG $

38  COND      ERROR1,NOMGG $

39  EMA       GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT    MGG $

41  COND      LGPWG,GRDPNT $


42  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP       OGPWG,,,,,// $

44  LABEL     LGPWG $

45  EQUIV     KGGX,KGG/NOGENL $

46  CHKPNT    KGG $

47  COND      LBL11A,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 2

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

49  CHKPNT   KGG $

50  LABEL    LBL11A $

51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

52  JUMP     LBL11 $
------------------------------------------------- Top of DMAP Loop
53  LABEL    LBL11 $

54  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

55  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

56  COND     ERROR3,NOL $

57  COND     ERROR4,REACT $

58  PURGE    GM/MPCF1/GO,KOO,LOO,MOO,MOA,PO,UOOV,RUOV/OMIT/KSS,KFS,PS/
             SINGLE $

59  CHKPNT   GM,RG,GO,KOO,LOO,MOO,MOA,PO,KSS,KFS,YS,PS,USET,ASET,RUOV $

60  COND     LBL4,GENEL $

61  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

62  SAVE     NOGPST $

63  COND     LBL4,NOGPST $

64  OFP      OGPST,,,,,// $

65  LABEL    LBL4 $

66  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $


67  CHKPNT   KNN,MNN $

68  COND     LBL2,MPCF2 $

69  MCE1     USET,RG/GM $

70  CHKPNT   GM $

71  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

72  CHKPNT   KNN,MNN $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 2

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73   LABEL    LBL2 $
74   EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
75   CHKPNT   KFF,MFF $
76   COND     LBL3,SINGLE $
77   SCE1     USET,KNN,MNN,,/KFF,KFS,KSS,MFF,, $
78   CHKPNT   KFS,KSS,KFF,MFF $
79   LABEL    LBL3 $
80   EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $
81   CHKPNT   KAA,MAA $
82   COND     LBL5,OMIT $
83   SMP1     USET,KFF,MFF,,/GO,KAA,KOO,LOO,MAA,MOO,MOA,, $
84   CHKPNT   GO,KAA,KOO,LOO,MAA,MOO,MOA $
85   LABEL    LBL5 $
86   RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
87   CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $
88   RBMG2    KLL/LLL $
89   CHKPNT   LLL $
90   RBMG3    LLL,KLR,KRR/DM $
91   CHKPNT   DM $
92   RBMG4    DM,MLL,MLR,MRR/MR $

93   CHKPNT   MR $
94   SSG1     SLT,BGPDT,CSTM,SIL,EST ,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $
95   CHKPNT   PG $
96   SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
97   CHKPNT   QR,PO,PS,PL $
98   SSG4     PL,QR,PO,MR,MLR,DM,MLL,MOO,MOA,GO,USET/PLI,POI/V,N,OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 2

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  CHKPNT   PLI,POI $

100  SSG3     LLL,KLL,PLI,LOO,KOO,POI/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,
              IRES=-1/V,N,NSKIP/V,N,EPSI $

101  SAVE     EPSI $

102  CHKPNT   ULV,UOOV,RULV,RUOV $

103  COND     LBL9,IRES $

104  MATGPR   GPL,USET,SIL,RULV//C,N,L $

105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

106  LABEL    LBL9 $

107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/UGV,PGG,QG/V,N,NSKIP/
              C,N,STATICS $

108  CHKPNT   UGV,QG,PGG $

109  COND     LBL8,REPEAT $

110  REPT     LBL11,360 $
---------------------------------------------------------- Bottom of DMAP Loop
111  JUMP     ERROR2 $

112  PARAM    //C,N,NOT/V,N,TEST/V,N,REPEAT $

113  COND     ERROR5,TEST $

114  LABEL    LBL8 $

115  CHKPNT   CSTM $

116  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $

117  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $


118  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

119  SAVE     CARDNO $

120  COND     P2,JUMPPLOT $

121  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

122  SAVE     PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 2

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  PRTMSG   PLOTX2// $
124  LABEL    P2 $
125  JUMP     FINIS $
126  LABEL    ERROR1 $
127  PRTPARM  //C,N,-1/C,N,INERTIA $
128  LABEL    ERROR2 $
129  PRTPARM  //C,N,-2/C,N,INERTIA $
130  LABEL    ERROR3 $
131  PRTPARM  //C,N,-3/C,N,INERTIA $
132  LABEL    ERROR4 $
133  PRTPARM  //C,N,-4/C,N,INERTIA $
134  LABEL    ERROR5 $
135  PRTPARM  //C,N,-5/C,N,INERTIA $
136  LABEL    FINIS $
137  END      $
```

3.3.2 Description of DMAP Operations for Static Analysis with Inertia Relief

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 126 and print error message if there are no structure elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 126 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

53. Beginning of Loop for additional constraint sets.

54. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

56. Go to DMAP No. 130 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 132 and print error message if no free-body supports.

60. Go to DMAP No. 65 if general elements present.

61. GPSP determines if possible grid point singularities remain.

63. Go to DMAP No. 65 if grid point singularities remain.

64. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

66. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

68. Go to DMAP No. 73 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

69. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

71. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

74. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

76. Go to DMAP No. 79 if no single-point constraints.

77. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

80. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

82. Go to DMAP No. 85 if no omitted coordinates.

83. SMP1 partitions constrained stiffness and mass matrices

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] \quad \text{and} \quad [M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reductions $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

and $[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$

86. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right].$$

88. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

90. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

92. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

94. SSG1 generates static load vectors $\{P_g\}$.

96. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

98. SSG4 calculates inertia loads and combines them with static loads

$$\{P_\ell^i\} = \{P_\ell\} + \Big([M_{\ell\ell}][D] + [M_{\ell r}]\Big)[m_r]^{-1}\{q_r\} \qquad \text{and}$$

$$\{P_o^i\} = \{P_o\} + \Big([M_{oo}][G_o] + [M_{ao}^T]\Big)\left[\frac{D}{I}\right][m_r]^{-1}\{q_r\} .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell^i\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o^i\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell^i\} = \{P_\ell^i\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell^i\}}{\{P_\ell^i\}^T\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o^i\} = \{P_o^i\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o^i\}}{\{P_o^i\}^T\{u_o^o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\left\{\begin{array}{c} u_\ell \\ \hline u_r \end{array}\right\} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} ,$$

$$\left\{\begin{array}{c} u_a \\ \hline u_o \end{array}\right\} = \{u_f\} , \qquad \left\{\begin{array}{c} u_f \\ \hline Y_s \end{array}\right\} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \left\{\begin{array}{c} u_n \\ \hline u_m \end{array}\right\} = \{u_g\}$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

109. Go to DMAP No. 114 if all constraint sets have been processed.

110. Go to DMAP No. 53 if additional sets of constraints need to be processed.

111. Go to DMAP No. 128 and print error message if number of loops exceeds 360.

113. Go to DMAP No. 134 and print error message if multiple boundary conditions are attempted with improper subset.

116. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

118. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

120. Go to DMAP No. 124 if no deformed structure plots are requested.

121. PLØT generates all requested deformed structure and contour plots.

123. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

125. Go to DMAP No. 136 and make normal exit.

127. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

129. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

131. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

133. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 4 - FREE-BØDY SUPPØRTS ARE REQUIRED.

135. STATIC ANALYSIS WITH INERTIA RELIEF ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN A NØN-LØØPING SUBSET.

3.3.3 Case Control Deck and Parameters for Static Analysis with Inertia Relief

The following items relate to subcase definition and data selection for Static Analysis with Inertia Relief:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection.

3. An SPC set may be selected only if used to remove grid point singularities or some, but not all, of the free body motions. At least one free body support must be provided with a SUPØRT card in the Bulk Data Deck.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets for the same output item.

The following output may be requested for Static Analysis with Inertia Relief:

1. Displacements at selected grid points due to the sum of the applied loads and the inertia loads.

2. Nonzero components of the applied static loads at selected grid points.

3. Reactions on free-body supports due to applied loads (single-point forces of constraint).

4. Forces and stresses in selected elements due to the sum of the applied loads and inertia loads.

5. Undeformed and deformed plots of the structural model.

6. Contour plots of stress and displacement.

The following parameters are used in Static Analysis with Inertia Relief:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3.4 NORMAL MODE ANALYSIS

3.4.1 DMAP Sequence for Normal Mode Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 3

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN     NO.3 NORMAL MODES ANALYSIS - SERIES 0 $
    2  FILE      LAMA=APPEND/PHIA=APPEND $
    3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                 NOGPDT $
    4  SAVE      LUSET $
    5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $
    6  GP2       GEOM2,EQEXIN/ECT $
    7  CHKPNT    ECT $
    8  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $
    9  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $
   10  COND      P1,NOPCDB $
   11  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                 JUMPPLOT=-1 $
   12  SAVE      NSIL,JUMPPLOT $
   13  PRTMSG    PLTSETX// $
   14  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $
   15  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $
   16  COND      P1,JUMPPLOT $
   17  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                 NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
   18  SAVE      JUMPPLOT,PLTFLG,PFILE $

   19  PRTMSG    PLOTX1//$
   20  LABEL     P1 $
   21  CHKPNT    PLTPAR,GPSETS,ELSETS $
   22  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $
   23  CHKPNT    GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  TA1     ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
            NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE    NOGENL,NOSIMP,GENEL $

26  COND    ERROR1,NOSIMP $

27  PURGE   OGPST/GENEL $

28  CHKPNT  EST,GPECT,GEI,OGPST $

29  PARAM   //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM   //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG     EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
            N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
            CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
            CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE    NOKGGX,NOMGG $

33  CHKPNT  KELM,KDICT,MELM,MDICT $

34  COND    JMPKGG,NOKGGX $

35  EMA     GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT  KGGX,GPST $

37  LABEL   JMPKGG $

38  COND    ERROR1,NOMGG $

39  EMA     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT  MGG $

41  COND    LGPWG,GRDPNT $

42  GPWG    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP     OGPWG,,,,,// $

44  LABEL   LGPWG $

45  EQUIV   KGGX,KGG/NOGENL $

46  CHKPNT  KGG $

47  COND    LBL11,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

49  CHKPNT  KGG $

50  LABEL   LBL11 $

51  PARAM   //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

52  GP4     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
            V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
            N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

53  SAVE    MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

54  COND    ERROR3,NOL $

55  PURGE   KRR,KLR,DM,MLR,MR/REACT/GM/MPCF1/GO/OMIT/KFS/SINGLE/QG/NOSET $

56  CHKPNT  KRR,KLR,DM,MLR,MR,GM,RG,GO,KFS,QG,USET,ASET $

57  COND    LBL4,GENEL $

58  GPSP    GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

59  SAVE    NOGPST $

60  COND    LBL4,NOGPST $

61  OFP     OGPST,,,,,// $

62  LABEL   LBL4 $

63  EQUIV   KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

64  CHKPNT  KNN,MNN $

65  COND    LBL2,MPCF2 $

66  MCE1    USET,RG/GM $


67  CHKPNT  GM $

68  MCE2    USET,GM,KGG,MGG,,/KNN,MNN,, $

69  CHKPNT  KNN,MNN $

70  LABEL   LBL2 $

71  EQUIV   KNN,KFF/SINGLE/MNN,MFF/SINGLE $

72  CHKPNT  KFF,MFF $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  COND      LBL3,SINGLE $
74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $
75  CHKPNT    KFS,KFF,MFF $
76  LABEL     LBL3 $
77  EQUIV     KFF,KAA/OMIT $
78  EQUIV     MFF,MAA/OMIT $
79  CHKPNT    KAA,MAA $
80  COND      LBL5,OMIT $
81  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
82  CHKPNT    GO,KAA $
83  SMP2      USET,GO,MFF/MAA $
84  CHKPNT    MAA $
85  LABEL     LBL5 $
86  COND      LBL6,REACT $
87  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
88  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $
89  RBMG2     KLL/LLL $
90  CHKPNT    LLL $
91  RBMG3     LLL,KLR,KRR/DM $
92  CHKPNT    DM $

93  RBMG4     DM,MLL,MLR,MRR/MR $
94  CHKPNT    MR $
95  LABEL     LBL6 $
96  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
97  SAVE      NOEED $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  COND      ERROR2,NOEED $

 99  CHKPNT    EED $

100  PARAM     //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

101  READ      KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
               NEIGV $

102  SAVE      NEIGV $

103  CHKPNT    LAMA,PHIA,MI,OEIGS $

104  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

105  OFP       LAMA,OEIGS,,,,//V,N,CARDNO $

106  SAVE      CARDNO $

107  COND      FINIS,NEIGV $

108  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $

109  CHKPNT    PHIG,QG $

110  PARAM     //C,N,MPY/V,N,SIXSIL/V,N,NSIL/C,N,6 $

111  PARAM     //C,N,EQ /V,N,SCALAR/V,N,SIXSIL/V,N,LUSET $

112  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $

113  CHKPNT    SIP,BGPDP $

114  COND      LBL7,SCALAR $

115  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $

116  SAVE      LUSEP $

117  CHKPNT    BGPDP,SIP $


118  LABEL     LBL7 $

119  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,,/ ,
               OQG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $

120  OFP       OPHIG,OQG1,OEF1,OES1,,//V,N,CARDNO $

121  SAVE      CARDNO $

122  COND      P2,JUMPPLOT $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

124  SAVE     PFILE $

125  PRTMSG   PLOTX2// $

126  LABEL    P2 $

127  JUMP     FINIS $

128  LABEL    ERROR1 $

129  PRTPARM  //C,N,-1/C,N,MODES $

130  LABEL    ERROR2 $

131  PRTPARM  //C,N,-2/C,N,MODES $

132  LABEL    ERROR3 $

133  PRTPARM  //C,N,-3/C,N,MODES $

134  LABEL    FINIS $

135  END      $
```

3.4.2 Description of DMAP Operations for Normal Mode Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 128 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 128 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining numbers of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

54. Go to DMAP No. 132 and print error message if no independent degrees of freedom are defined.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right].$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||} .$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

98 Go to DMAP No. 130 and print error message if no Eigenvalue Extraction Data.

101. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D\,\phi_{ro} \\ \hline \phi_{ro} \end{array}\right] \quad .$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

105. ØFP formats eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

107. Go to DMAP No. 134 and exit if no eigenvalues found.

108. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \quad \begin{Bmatrix} \phi_a \\ \hline \phi_o \end{Bmatrix} = \{\phi_f\} \quad ,$$

$$\begin{Bmatrix} \phi_f \\ \hline \phi_s \end{Bmatrix} = \{\phi_n\} \quad , \quad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\begin{Bmatrix} \phi_n \\ \hline \phi_m \end{Bmatrix} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

112. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

114. Go to DMAP No. 118 if no scalar points.

115. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

119. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØQG1) for output and translation components of the eigenvectors (PPHIG).

120. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

122. Go to DMAP No. 126 if no deformed structure plots are requested.

123. PLØT generates all requested deformed structure and contour plots.

125. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

127. Go to DMAP No. 134 and make normal exit.

to select an EIGR card that avoids the extraction of previously found eigenvalues. This is particularly important following unscheduled exits due to insufficient time to find all eigenvalues in the range of interest.

3. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

The following output may be requested for Normal Mode Analysis:

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

5. Contour plots of stress and displacement for selected modes.

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

NORMAL MODE ANALYSIS

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the frequency range specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergence failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
   (1) Normal termination.
   (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
   (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

The following summary of the eigenvalue analysis performed, using the Tridiagonal Reduction (FEER - Fast Eigenvalue Extraction Routine) method, is automatically printed.

1. Number of eigenvalues extracted.
2. Number of starting points used.
   This corresponds to the total number of random starting and restart vectors used by the FEER process.

C-5

3. Number of starting point moves.

   Not used in FEER (set equal to zero).

4. Number of triangular decompositions.

   Always equal to one, except for unshifted vibration problems (roots starting from the lowest requested). In this case a maximum of three shifts and three decompositions are employed to remove possible stiffness matrix singularities.

5. Total number of vector iterations.

   The total number of reorthogonalizations of all the trial vectors employed.

6. Reason for termination.

   (0) Normal termination.

   (1) Fewer than the requested number of eigenvalues and eigenvectors have been extracted.

   (3) The problem size has been reduced. However, the desired number of accurate eigensolutions specified on the EIGB or EIGR card may have been obtained. A detailed list of the computed error bounds can be obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK.

7. Largest off-diagonal modal mass term and the number failing the mass orthogonality criterion.

3.4.4 Case Control Deck and Parameters for Normal Mode Analysis

The following items relate to subcase definition and data selection for Normal Modes:

1. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.

2. On restart, the current EIGR card controls the eigenvalue extraction, regardless of what calculations were made in the previous execution. Consequently, when making restarts with either the Determinant method or the Inverse Power method, METHØD should be changed.

to select an EIGR card that avoids the extraction of previously found eigenvalues. This is particularly important following unscheduled exits due to insufficient time to find all eigenvalues in the range of interest.

3. An SPC set must be selected unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.

4. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

The following output may be requested for Normal Mode Analysis:

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

5. Contour plots of stress and displacement for selected modes.

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.4.5 Automatic Alters for Automated Multi-stage Substructuring

The following lines of the Normal Modes Analysis, Rigid Format 3, are altered in automatic substructure analyses.

Phase 1: 53, 86-95, 96-126

Phase 2: 3-4, 10-21, 26, 38, 45-48, 57-62, 119-126

Phase 3: 86-95, 100-107, 108

If APP DISP,SUBS is used, the user may also specify ALTER's. However, these must not interfere with the automatically generated DMAP statement ALTER's listed above. See Section 5.9 for a description and listing of the ALTER's which are automatically generated for substructuring.

3.4.6 Optional Diagnostic Output for FEER

Special detailed information related to the generation of the reduced problem size, the elements of the reduced tridiagonal matrix, computed error bounds and other numerical tests can be obtained by requesting DIAG 16 in the NASTRAN Executive Control Deck.

The meaning of this information is explained below in the order in which it appears in the DIAG 16 output.

ØRDER - The order of the unreduced problem (size of the $[K_{aa}]$ matrix)

MAX RANK - The maximum number of existing finite eigensolutions as initially detected by FEER

RED ØRDER - The order of the reduced eigenproblem which will be solved to obtain the number of accurate solutions requested by the user

ØRTH VCT - The number of previously computed accurate eigenvectors on the eigenvector file which were generated prior to a restart or by the NASTRAN rigid body mode generator

USER SHIFT - The user specified shift after conversion from cycles to radians - squared (used only in frequency problems).

INTERNAL SHIFT- A small positive value automatically computed to remove singularities if the user has specified a zero shift. Otherwise, the negative of the user shift (used only in frequency problems).

SINGULARITY CHECK - PASS: the shifted stiffness matrix is non-singular
- ****: the number of internal shifts needed to remove stiffness matrix singularities

TRIDIAGONAL ELEMENTS ROW j, **, ***, **** - The computed tridiagonal elements of the reduced eigenmatrix:
- j - Matrix row
- ** - Diagonal element
- *** - Off-diagonal element
- **** - First estimate of off-diagonal element in the next row

ØRTH ITER - The number of times a reorthogonalization of a trial vector has been performed

MAX PRØJ - The maximum projection of the above trial vector on the previously computed accurate trial vectors (prior to the current reorthogonalization)

NØRMAL FACT - The normalization factor for the reorthogonalized trial vector

ØPEN CØRE NØT USED *** FEER3 - Open core not used by Subroutine FEER3, in single-precision words

FEER QRW ELEMENT *, ITER **, ***, RATIØ ****, PRØJ *****:

* - The internal eigenvalue number in the order of its extraction by FEER

** - The number of inverse power iterations performed to extract the associated eigenvector of the reduced system (this is not a physical eigenvector)

*** - If a multiple root has been detected, the number of times that the previous multiple-root, reduced-system eigenvectors have been projected out of the current multiple-root eigenvector before repeating the inverse power iterations

**** - The absolute ratio of maximum, reduced-system eigenvector elements for successive inverse power iterations

***** - The maximum projection of a current multiple-root eigenvector on previously computed eigenvectors for the same root

PHYSICAL EIGENVALUE *, **, THEØR ERRØR *** PERCENT, PASS ØR FAIL:

* - The internal eigenvalue number in the order of its extraction by FEER

** - The associated physical eigenvalue (λ for buckling problems, ω^2 for frequency problems)

*** - Theoretical upper bound on the relative eigenvalue error

PASS - The computed error is less than or equal to the allowable specified on the EIGB or EIGR bulk data card (default is .001/n where n is the order of the stiffness matrix)

FAIL - The computed error is greater than the allowable and this mode is not accepted for further processing

ØPEN CØRE NØT USED *** FEER4 - Open core not used by Subroutine FEER4, in single precision words

FEER CØMPLETE *, **, ***, ****

* - The remaining CPU time available following decomposition of the shifted stiffness matrix, in seconds (the total time is specified on the TIME card in the Executive Control Deck)

** - The remaining CPU time, in seconds after completing Subroutine FEER3

*** - The remaining CPU time, in seconds after completing Subroutine FEER4

**** - The total operation count for FEER after decomposition of the shifted stiffness matrix. One operation is considered to be a multiplication or division followed by an addition

3.5 STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

3.5.1 DMAP Sequence for Static Analysis with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO       ERR=2    NOLIST   NODECK   NOREF    NOOSCAR

    1   BEGIN     NO.4 DIFFERENTIAL STIFFNESS ANALYSIS - SERIES 0 $

    2   GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                  NOGPDT $

    3   SAVE      LUSET,NOGPDT $

    4   COND      ERROR1,NOGPDT $

    5   CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6   GP2       GEOM2,EQEXIN/ECT $

    7   CHKPNT    ECT $

    8   PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9   PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10   COND      P1,NOPCDB $

   11   PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                  JUMPPLOT=-1 $

   12   SAVE      NSIL,JUMPPLOT $

   13   PRTMSG    PLTSETX// $

   14   PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15   PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16   COND      P1,JUMPPLOT $

   17   PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                  NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18   SAVE      JUMPPLOT,PLTFLG,PFILE $


   19   PRTMSG    PLOTX1// $

   20   LABEL     P1 $

   21   CHKPNT    PLTPAR,GPSETS,ELSETS $

   22   GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23   SAVE      NOGRAV $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

25  CHKPNT   SLT,GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  COND     ERROR1,NOSIMP $

29  PURGE    OGPST/GENEL $

30  CHKPNT   EST,GPECT,GEI,OGPST $

31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

33  SAVE     NOKGGX,NOMGG $

34  CHKPNT   KELM,KDICT,MELM,MDICT $

35  COND     JMPKGG,NOKGGX $

36  EMA      GPECT,KDICT,KELM/KGGX,GPST $

37  CHKPNT   KGGX,GPST $

38  LABEL    JMPKGG $

39  COND     JMPMGG,NOMGG $

40  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

41  CHKPNT   MGG $


42  LABEL    JMPMGG $

43  COND     LBL1,GRDPNT $

44  COND     ERROR4,NOMGG $

45  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

46  OFP      OGPWG,,,,,// $

47  LABEL    LBL1 $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  EQUIV    KGGX,KGG/NOGENL $

49  CHKPNT   KGG $

50  COND     LBL11,NOGENL $

51  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

52  CHKPNT   KGG $

53  LABEL    LBL11 $

54  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

55  CASE     CASECC,/CASEXX/C,N,TRANRESP/C,N,0/V,N,NOLOOP $

56  GP4      CASEXX,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

57  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

58  COND     ERROR5,NOL $

59  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE/
             UBOOV/OMIT/YBS,PBS,KBFS,KBSS,KDFS,KDSS/SINGLE $

60  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,   UBOOV,
             YBS,PBS,KBFS,KBSS,KDFS,KDSS,QG $

61  COND     LBL4D,REACT $

62  JUMP     ERROR2 $

63  LABEL    LBL4D $

64  COND     LBL4,GENEL$

65  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $


66  SAVE     NOGPST $

67  COND     LBL4,NOGPST $

68  OFP      OGPST,,,,,// $

69  LABEL    LBL4 $

70  EQUIV    KGG,KNN/MPCF1 $

71  CHKPNT   KNN $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
72  COND      LBL2,MPCF2 $

73  MCE1      USET,RG/GM $

74  CHKPNT    GM $

75  MCE2      USET,GM,KGG,,,/KNN,,, $

76  CHKPNT    KNN $

77  LABEL     LBL2 $

78  EQUIV     KNN,KFF/SINGLE $

79  CHKPNT    KFF $

80  COND      LBL3,SINGLE $

81  SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $

82  CHKPNT    KFS,KSS,KFF $

83  LABEL     LBL3 $

84  EQUIV     KFF,KAA/OMIT $

85  CHKPNT    KAA $

86  COND      LBL5,OMIT $

87  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

88  CHKPNT    GO,KAA,KOO,LOO $

89  LABEL     LBL5 $

90  RBMG2     KAA/LLL $

91  CHKPNT    LLL $


92  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASEXX,DIT/PG/V,N,
              LUSET/C,N,1 $

93  CHKPNT    PG $

94  EQUIV     PG,PL/NOSET $

95  CHKPNT    PL $

96  COND      LBL10,NOSET $

97  SSG2      USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
```

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 4

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


 98   CHKPNT    PO,PS,PL $

 99   LABEL     LBL10 $

100   SSG3      LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
                C,N,1/V,N,EPSI $

101   SAVE      EPSI $

102   CHKPNT    ULV,UOOV,RULV,RUOV $

103   COND      LBL9,IRES $

104   MATGPR    GPL,USET,SIL,RULV//C,N,L $

105   MATGPR    GPL,USET,SIL,RUOV//C,N,O $

106   LABEL     LBL9 $

107   SDR1      USET,,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PG1,QG/C,N,1/C,N,DSO $

108   CHKPNT    UGV,QG $

109   SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PG/
                OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,DSO $

110   PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

111   OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

112   SAVE      CARDNO $

113   COND      P2,JUMPPLOT $

114   PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
                PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115   SAVE      PFILE $

116   PRTMSG    PLOTX2// $


117   LABEL     P2 $

118   TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
                NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

119   DSMG1     CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
                DSCOSETS

120   CHKPNT    KDGG $

121   PARAM     //C,N,ADD/V,N,SHIFT/C,N,-1/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  PARAM    //C,N,ADD/V,N,COUNT/V,N,ALWAYS=-1/V,N,NEVER= 1 $
123  PARAMR   //C,N,ADD/V,N,DSEPS1/C,N,0.0/C,N,0.0 $
124  PARAML   YS//C,N,NULL/C,N,/C,N,/C,N,/V,N,NOYS $
125  JUMP     OUTLPTOP $
                                          Top of Stiffness Adjustment Loop
126  LABEL    OUTLPTOP $
127  EQUIV    PG,PG1/NOYS $
128  CHKPNT   PG1 $
129  PARAM    //C,N,KLOCK/V,N,TO $
130  EQUIV    KDGG,KDNN/MPCF2 $
131  CHKPNT   KDNN $
132  COND     LBL2D,MPCF2 $
133  MCE2     USET,GM,KDGG,,,/KDNN,,, $
134  CHKPNT   KDNN $
135  LABEL    LBL2D $
136  EQUIV    KDNN,KDFF/SINGLE $
137  CHKPNT   KDFF $
138  COND     LBL3D,SINGLE $
139  SCE1     USET,KDNN,,,/KDFF,KDFS,KDSS,,, $
140  CHKPNT   KDFF,KDFS,KDSS $
141  LABEL    LBL3D $

142  EQUIV    KDFF,KDAA/OMIT $
143  CHKPNT   KDAA $
144  COND     LBL5D,OMIT $
145  SMP2     USET,GO,KDFF/KDAA $
146  CHKPNT   KDAA $
147  LABEL    LBL5D $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
148  ADD      KAA,KDAA/KBLL $

149  ADD      KFS,KDFS/KBFS $

150  ADD      KSS,KDSS/KBSS $

151  COND     PGOK,NOYS $

152  MPYAD    KBSS,YS,/PSS/C,N,0/C,N,1/C,N,1/C,N,1 $

153  MPYAD    KBFS,YS,/PFS/C,N,0/C,N,1/C,N,1/C,N,1 $

154  UMERGE   USET,PFS,PSS/PN/C,N,N/C,N,F/C,N,S $

155  EQUIV    PN,PGX/MPCF2 $

156  COND     LBL6D,MPCF2 $

157  UMERGE   USET,PN,/PGX/C,N,G/C,N,N/C,N,M $

158  LABEL    LBL6D $

159  ADD      PGX,PG/PGG/C,N,(-1.0,0.0) $

160  EQUIV    PGG,PG1/ALWAYS $

161  LABEL    PGOK $

162  ADD      PG1,/PGO/ $

163  RBMG2    KBLL/LBLL/V,N,POWER/V,N,DET $

164  SAVE     DET,POWER $

165  CHKPNT   LBLL $

166  PRTPARM  //C,N,0/C,N,DET $

167  PRTPARM  //C,N,0/C,N,POWER $


168  JUMP     INLPTOP $
----------------------------------------------------- Top of Load Correction Loop
169  LABEL    INLPTOP $

170  PARAM    //C,N,KLOCK/V,N,TI $

171  SSG2     USET,GM,YS,KDFS,GO,,PG1/,PBO,PBS,PBL $

172  SSG3     LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NOSKIP/V,N,
              EPSI $

173  SAVE     EPSI $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
174  CHKPNT   UBLV,RUBLV $

175  COND     LBL9D,IRES $

176  MATGPR   GPL,USET,SIL,RUBLV//C,N,L $

177  LABEL    LBL9D $

178  SDR1     USET,,UBLV,,YS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/C,N,1/C,N,DS1 $

179  CHKPNT   UBGV,QBG $

180  ADD      UBGV,UGV/DUGV/C,N,(-1.0,0.0) $

181  DSMG1    CASECC,GPTT,SIL,EDT,DUGV,CSTM,MPT,ECPT,GPCT,DIT/DKDGG/V,N,
              DSCOSET $

182  CHKPNT   DKDGG $

183  MPYAD    DKDGG,UBGV,PGO/PGI1/C,N,0/C,N,1/C,N,1/C,N,1 $

184  DSCHK    PG1,PG11,UBGV//C,Y,EPSIO=1.E-5/V,N,DSEPSI/C,Y,NT=10/V,N,TO/V,N,
              TI/V,N,DONE/V,N,SHIFT/V,N,COUNT/C,Y,BETAD=4 $

185  SAVE     DSEPSI,DONE,SHIFT,COUNT $

186  COND     DONE,DONE $

187  COND     SHIFT,SHIFT $

188  EQUIV    PG,PG1/NEVER $

189  EQUIV    PG11,PG1/ALWAYS $

190  EQUIV    PG1,PG11/NEVER $

191  REPT     INLPTOP,1000 $
--------------------------------------------------- Bottom of Load Correction Loop
192  TABPT    PG11,PG1,PG,,// $


193  LABEL    SHIFT $

194  ADD      DKDGG,KDGG/KDGG1/C,N,(-1.0,0.0) $

195  CHKPNT   KDGG1 $

196  EQUIV    UBGV,UGV/ALWAYS/KDGG1,KDGG/ALWAYS $

197  CHKPNT   KDGG $

198  EQUIV    KDGG,KDGG1/NEVER/UGV,UBGV/NEVER $
```

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 4

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
199  REPT     OUTLPTUP,1000 $
                                                   Bottom of Stiffness Adjustment Loop
200  TABPT    KDGG1,KDGG,UGV,,// $

201  LABEL    DONE $

202  CHKPNT   CSTM $

203  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,,/
              ,OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

204  OFP      OUBGV1,OQBG1,OEFB1,OESB1,,//V,N,CARDNO $

205  SAVE     CARDNO $

206  COND     P3,JUMPPLOT $

207  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUBGV1,,GPECT,
              OESB1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
              PFILE $

208  SAVE     PFILE $

209  PRTMSG   PLOTX3// $

210  LABEL    P3 $

211  JUMP     FINIS $

212  LABEL    ERROR1 $

213  PRTPARM  //C,N,-1/C,N,DIFFSTIF $

214  LABEL    ERROR2 $

215  PRTPARM  //C,N,-2/C,N,DIFFSTIF $

216  LABEL    ERROR4 $

217  PRTPARM  //C,N,-4/C,N,DIFFSTIF $


218  LABEL    ERROR5 $

219  PRTPARM  //C,N,-5/C,N,DIFFSTIF $

220  LABEL    FINIS $

221  END      $
```

3.5.2 Description of DMAP Operations for Static Analysis with Differential Stiffness

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

4. Go to DMAP No. 211 if no grid point definition table.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 211 and print error message if no structural elements.

32. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K_{gg}^x]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no weight and balance is requested.

44. Go to DMAP No. 215 and print error message if no mass matrix exists.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

48. Equivalence $[K_{gg}^x]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K_{gg}^x]$ to obtain stiffness matrix $[K_{gg}]$.

56. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

58. Go to DMAP No. 218 and print error message if no independent degrees of freedom are defined.

61. Go to DMAP No. 63 if no free-body supports supplied.

64. Go to DMAP No. 69 if general elements present.

65. GPSP determines if possible grid point singularities remain.

67. Go to DMAP No. 69 if no Grid Point Singularity Table.

68. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

70. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

80. Go to DMAP No. 83 if no single-point constraints.

81. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

86. Go to DMAP No. 89 if no omitted coordinates.

87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RMBG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$

92. SSG1 generates static load vectors $\{P_g\}$.

94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

96. Go to DMAP No. 99 if no constraints applied.

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \left\{\begin{matrix} \bar{P}_n \\ \hline P_m \end{matrix}\right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{matrix} \bar{P}_f \\ \hline P_s \end{matrix}\right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{\begin{matrix} P_a \\ \hline P_o \end{matrix}\right\} \quad \text{and} \quad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{aa}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{aa}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV).

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

109. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1) and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no deformed static solution structure plots are requested.

114. PLØT generates all requested static solution deformed structure and contour plots.

116. PRTMSG prints plotter data, engineering data, and contour data for each deformed static solution plot generated.

118. TA1 generates element tables for use in differential stiffness matrix assembly.

119. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

125. Go to next DMAP instruction if cold start or modified restart. ØUTLPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

126. Beginning of outer (stiffness adjustment) loop for differential stiffness iteration.

127. Equivalence $\{P_g\}$ to $\{P_{g1}\}$ if no enforced displacements.

130. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

132. Go to DMAP No. 135 if no multipoint constraints.

133. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

136. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ if no single-point constraints.

138. Go to DMAP No. 141 if no single-point constraints.

139. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \left[\begin{array}{c|c} K^d_{ff} & K^d_{fs} \\ \hline K^d_{sf} & K^d_{ss} \end{array}\right].$$

142. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ if no omitted coordinates.

144. Go to DMAP No. 147 if no omitted coordinates.

145. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{oa}]^T[G_o] + [G_o]^T[K^d_{oa}] + [G_o]^T[K^d_{oo}][G_o]$.

148. ADD $[K_{aa}]$ and $[K^d_{aa}]$ to form $[K^b_{\ell\ell}]$.

149. ADD $[K_{fs}]$ and $[K^d_{fs}]$ to form $[K^b_{fs}]$.

150. ADD $[K_{ss}]$ and $[K^d_{ss}]$ to form $[K^b_{ss}]$.

151. Go to DMAP No. 160 if no enforced displacements.

152. MPYAD multiply $[K^b_{ss}]$ and $\{Y_s\}$ to form $\{P_{ss}\}$.

153. MPYAD multiply $[K^b_{fs}]$ and $\{Y_s\}$ to form $\{P_{fs}\}$.

154. UMERGE expand $\{P_n\}$ to form $\{P^x_g\}$.

159. ADD $-\{P^x_g\}$ and $\{P_g\}$ to form $\{P_{gg}\}$.

160. Equivalence $\{P_{gg}\}$ to $\{P_{gl}\}$.

162. ADD $\{P_{gl}\}$ and nothing to create $\{P_{go}\}$.

163. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix.

$$[K^b_{\ell\ell}] = [L^b_{\ell\ell}][U^b_{\ell\ell}].$$

166. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

167. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

168. Go to next DMAP instruction if cold start or modified restart. INLPTØP will be altered by the executive system to the proper location inside the loop for unmodified restarts within the loop.

169. Beginning of inner (load correction) loop for differential stiffness iteration.

171. SSG2 applies constraints to static load vectors

$$\{P_{gl}\} = \begin{Bmatrix} \bar{P}^b_n \\ \hline P^b_m \end{Bmatrix} , \qquad \{P^b_n\} = \{\bar{P}^b_n\} + [G^T_m]\{P^b_m\} ,$$

$$\{P^b_n\} = \begin{Bmatrix} \bar{P}^b_f \\ \hline P^b_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}^b_f\} - [K^d_{fs}]\{Y_s\} ,$$

$$\{P^b_f\} = \begin{Bmatrix} P^b_a \\ \hline P^b_o \end{Bmatrix} \quad \text{and} \quad \{P^b_\ell\} = \{P^b_a\} + [G^T_o]\{P^b_o\} .$$

172. SSG3 solves for displacements of independent coordinates for current differential stiffness load vector

$$\{u^b_\ell\} = [K^b_{\ell\ell}]^{-1}\{P^b_\ell\}$$

and calculates residual vector (RBULV) and residual vector error ratio for current differential stiffness load vector

$$\{\delta P^b_\ell\} = \{P^b_\ell\} - [K^b_{\ell\ell}]\{u^b_\ell\} ,$$

$$\varepsilon^b_\ell = \frac{\{u^b_\ell\}^T\{\delta P^b_\ell\}}{\{P^b_\ell\}^T\{u^b_\ell\}} .$$

174. Go to DMAP No. 177 if residual vector for current differential stiffness solution is not to be printed.

176. Print residual vector for current differential stiffness solution.

178. SDR1 recovers dependent displacements for current differential stiffness solution

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} , \quad \begin{Bmatrix} u_\ell^b \\ -- \\ u_o^b \end{Bmatrix} = \{u_f^b\} ,$$

$$\begin{Bmatrix} u_f^b \\ -- \\ Y_s^b \end{Bmatrix} = \{u_n^b\} , \quad \{u_m^b\} = [G_m]\{u_n^b\} ,$$

$$\begin{Bmatrix} u_n^b \\ -- \\ u_m^b \end{Bmatrix} = \{u_g^b\}$$

and recovers single-point forces of constraint for current differential stiffness solution

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} .$$

180. ADD $-\{U_g^b\}$ and $\{U_g\}$ to form $\{U_g^d\}$.

181. DSMG1 generates differential stiffness matrix $[\delta K_{gg}^d]$

183. MPYAD form load vector for inner loop iteration.

$$\{P_{g_{I1}}\} = [\delta K_{gg}^d]\{U_g^b\} + \{P_{go}\}$$

184. DSCHK performs differential stiffness convergence checks.

186. Go to DMAP No. 201 if differential stiffness iteration is complete.

187. Go to DMAP No. 193 if additional differential stiffness matrix changes are necessary for further iteration.

188. Equivalence breaks previous equivalence of $\{P_g\}$ to $\{P_{g1}\}$.

189. Equivalence $\{P_{g_{I1}}\}$ to $\{P_{g1}\}$

190. Equivalence breaks previous equivalence of $\{P_{g1}\}$ to $\{P_{g_{I1}}\}$.

191. Go to DMAP No. 169 for additional inner loop differential stiffness iteration.

192. TABPT table prints vectors $\{P_{g_{I1}}\}$, $\{P_{g1}\}$, and $\{P_g\}$.

194. ADD $-[\delta K_{gg}^d]$ and $[K_{gg}^d]$ to form $[K_{gg1}^d]$.

196. Equivalence $\{U_g^b\}$ to $\{U_g\}$ and $[K_{gg1}^d]$ to $[K_{gg}^d]$.

STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS

198. Equivalence breaks previous equivalence of $[K^d_{gg}]$ to $[K^d_{gg1}]$ and $\{U_g\}$ to $\{U^b_g\}$.

199. Go to DMAP No. 126 for additional outer loop differential stiffness iteration.

200. TABPT table prints $[K^d_{gg1}]$, $[K^d_{gg}]$, and $\{U_g\}$.

203. SDR2 calculates element forces (ØEFB1) and stresses (ØESB1) and prepares displacement vectors (ØUBGV1) and single-point forces of constraint (ØQBG1) for output and translation components of the displacement vector (PUBGV1) for the differential stiffness solution.

204. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

206. Go to DMAP No. 210 if no deformed differential stiffness solution plots are requested.

207. PLØT generates all requested deformed differential stiffness solution structure and contour plots.

209. PRTMSG prints plotter data, engineering data, and contour data for each deformed differential stiffness solution plot generated.

211. Go to DMAP No. 220 and make normal exit.

213. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

215. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

217. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIONS.

219. STATIC ANALYSIS WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.5.3 Automatic Output for Static Analysis with Differential Stiffness

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed for each differential stiffness loading condition.

Iterative differential stiffness computations are terminated for one of five reasons. Iteration termination reasons are automatically printed in an information message. These reasons have the following meanings:

1. REASON 0 means the iteration procedure was incomplete at the time of exit. This is caused by either an unexpected interruption of the iteration procedure (i.e., system abort) or termination is not scheduled (for the other four reasons) at the completion of the current iteration.

2. REASON 1 means the iteration procedure converged to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

3. REASON 2 means iteration procedure is diverging from the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

4. REASON 3 means insufficient time remaining to achieve convergence to the EPSIØ value supplied by the user on a PARAM bulk data card. (The default value of EPSIØ is 1.0E-5.)

5. REASON 4 means the number of iterations supplied by the user on a PARAM bulk data card has been met. (The default number of iterations is 10.)

Parameter values at the time of exit are automatically output as follows:

1. Parameter DØNE: -1 is normal; + N is the estimate of the number of iterations required to achieve convergence.

2. Parameter SHIFT: +1 indicates a return to the top of the inner loop was scheduled; -1 indicates a return to top of the outer loop was scheduled following the current iteration.

3. Parameter DSEPSI: the value of the ratio of energy error to total energy at the time of exit.

3.5.4 Case Control Deck and Parameters for Static Analysis with Differential Stiffness

The following items relate to subcase definition and data selection for Static Analysis with Differential Stiffness:

1. The Case Control Deck must contain two subcases.
2. A static loading condition must be defined above the subcase level with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
3. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.
4. Output requests that apply only to the linear solution must appear in the first subcase.
5. Output requests that apply only to the solution with differential stiffness must be placed in the second subcase.
6. Output requests that apply to both solutions, with and without differential stiffness may be placed above the subcase level.

The following output may be requested for Static Analysis with Differential Stiffness:

1. Nonzero Components of the applied static load for the linear solution at selected grid points.
2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.
3. Forces and stresses in selected elements, with and without differential stiffness.
4. Undeformed and deformed plots of the structural model.
5. Contour plots of stress and displacement.

The following parameters are used in Static Analysis with Differential Stiffness:

1. GROPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. COUPMASS - CPBAR, CPROD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

5. BETAD - optional - the integer value of this parameter is the assumed number of iterations for the inner loop in shift decisions for iterated differential stiffness. The default value is 4 iterations.

6. NT - optional - the integer value of this parameter limits the maximum number of iterations. The default value is 10 iterations.

7. EPSIO - optional - the real value of this parameter is used to test the convergence of iterated differential stiffness. The default value is 10^{-5}.

3.6 BUCKLING ANALYSIS

3.6.1 DMAP Sequence for Buckling Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    NO.5 BUCKLING ANALYSIS - SERIES 0 $

   2  FILE     LAMA=APPEND/PHIA=APPEND $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET $

   5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   6  GP2      GEOM2,EQEXIN/ECT $

   7  CHKPNT   ECT $

   8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  10  COND     P1,NOPCDB $

  11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

  12  SAVE     NSIL,JUMPPLOT $

  13  PRTMSG   PLTSETX// $

  14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  16  COND     P1,JUMPPLOT $

  17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  18  SAVE     JUMPPLOT,PLTFLG,PFILE $


  19  PRTMSG   PLOTX1// $

  20  LABEL    P1 $

  21  CHKPNT   PLTPAR,GPSETS,ELSETS $

  22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

  23  SAVE     NOGRAV $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

25  CHKPNT   SLT,GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  COND     ERROR1,NOSIMP $

29  PURGE    OGPST/GENEL $

30  CHKPNT   EST,GPECT,GEI,OGPST $

31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

33  SAVE     NOKGGX,NOMGG $

34  CHKPNT   KELM,KDICT,MELM,MDICT $

35  COND     JMPKGG,NOKGGX $

36  EMA      GPECT,KDICT,KELM/KGGX,GPST $

37  CHKPNT   KGGX,GPST $

38  LABEL    JMPKGG $

39  COND     JMPMGG,NOMGG $

40  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

41  CHKPNT   MGG $


42  LABEL    JMPMGG $

43  COND     LBL1,GRDPNT $

44  COND     ERROR3,NOMGG $

45  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

46  OFP      OGPWG,,,,,// $

47  LABEL    LBL1 $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  EQUIV    KGGX,KGG/NOGENL $

49  CHKPNT   KGG $

50  COND     LBL11,NOGENL $

51  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

52  CHKPNT   KGG $

53  LABEL    LBL11 $

54  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

55  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

56  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

57  COND     ERROR6,NOL $

58  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

59  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
             NOSR $

60  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $

61  COND     LBL4D,REACT $

62  JUMP     ERROR2 $

63  LABEL    LBL4D $

64  COND     LBL4,GENEL $

65  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

66  SAVE     NOGPST $


67  COND     LBL4,NOGPST $

68  OFP      OGPST,,,,,,// $

69  LABEL    LBL4 $

70  EQUIV    KGG,KNN/MPCF1 $

71  CHKPNT   KNN $

72  COND     LBL2,MPCF2 $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  MCE1     USET,RG/GM $
74  CHKPNT   GM $
75  MCE2     USET,GM,KGG,,,/KNN,,, $
76  CHKPNT   KNN $
77  LABEL    LBL2 $
78  EQUIV    KNN,KFF/SINGLE $
79  CHKPNT   KFF $
80  COND     LBL3,SINGLE $
81  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $
82  CHKPNT   KFS,KSS,KFF $
83  LABEL    LBL3 $
84  EQUIV    KFF,KAA/OMIT $
85  CHKPNT   KAA $
86  COND     LBL5,OMIT $
87  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
88  CHKPNT   GO,KAA,KOO,LOO $
89  LABEL    LBL5 $
90  RBMG2    KAA/LLL $
91  CHKPNT   LLL $
92  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
             LUSET/C,N,1 $

93  CHKPNT   PG $
94  EQUIV    PG,PL/NOSET $
95  CHKPNT   PL $
96  COND     LBL10,NOSET $
97  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
98  CHKPNT   PO,PS,PL $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  LABEL    LBL10 $

100  SSG3     LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
              C,N,1/V,N,EPSI $

101  SAVE     EPSI $

102  CHKPNT   ULV,UOOV,RULV,RUOV $

103  COND     LBL9,IRES $

104  MATGPR   GPL,USET,SIL,RULV//C,N,L $

105  MATGPR   GPL,USET,SIL,RUOV//C,N,O $

106  LABEL    LBL9 $

107  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
              BKLO $

108  CHKPNT   UGV,QG,PGG $

109  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $

111  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

112  SAVE     CARDNO $

113  COND     P2,JUMPPLOT $

114  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

115  SAVE     PFILE $

116  PRTMSG   PLOTX2// $

117  LABEL    P2 $


118  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
              NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

119  DSMG1    CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
              DSCOSET $

120  CHKPNT   KDGG $

121  EQUIV    KDGG,KDNN/MPCF2 $

122  CHKPNT   KDNN $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  COND     LBL2D,MPCF2 $
124  MCE2     USET,GM,KDGG,,,/KDNN,,, $
125  CHKPNT   KDNN $
126  LABEL    LBL2D $
127  EQUIV    KDNN,KDFF/SINGLE $
128  CHKPNT   KDFF $
129  COND     LBL3D,SINGLE $
130  SCE1     USET,KDNN,,,/KDFF,KDFS,,,, $
131  CHKPNT   KDFF,KDFS $
132  LABEL    LBL3D $
133  EQUIV    KDFF,KDAA/OMIT $
134  CHKPNT   KDAA $
135  COND     LBL5D,OMIT $
136  SMP2     USET,GO,KDFF/KDAA $
137  CHKPNT   KDAA $
138  LABEL    LBL5D $
139  ADD      KDAA,/KDAAM/C,N,(-1.0,0.0)/C,N,(0.0,0.0) $
140  CHKPNT   KDAAM $
141  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

142  SAVE     NOEED $
143  COND     ERROR3,NOEED $
144  CHKPNT   EED $
145  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
146  READ     KAA,KDAAM,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,BUCKLING/ V,N,
              NEIGV/C,N,2 $
147  SAVE     NEIGV $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
148  CHKPNT   LAMA,PHIA,OEIGS $
149  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $
150  SAVE     CARDNO $
151  COND     ERROR4,NEIGV $
152  SDR1     USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,BQG/C,N,1/C,N,BKL1 $
153  CHKPNT   PHIG,BQG $
154  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/,
              OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,BKL1 $
155  OFP      OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $
156  SAVE     CARDNO $
157  COND     P3,JUMPPLOT $
158  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
              OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
              PFILE $
159  SAVE     PFILE $
160  PRTMSG   PLOTX3// $
161  LABEL    P3 $
162  JUMP     FINIS $
163  LABEL    ERROR1 $
164  PRTPARM  //C,N,-1/C,N,BUCKLING $
165  LABEL    ERROR2 $
166  PRTPARM  //C,N,-2/C,N,BUCKLING $

167  LABEL    ERROR3 $
168  PRTPARM  //C,N,-3/C,N,BUCKLING $
169  LABEL    ERROR4 $
170  PRTPARM  //C,N,-4/C,N,BUCKLING $
171  LABEL    ERROR5 $
172  PRTPARM  //C,N,-5/C,N,BUCKLING $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 5

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
173  LABEL    ERROR6 $

174  PRTPARM  //C,N,-6/C,N,BUCKLING $

175  LABEL    FINIS $

176  END      $
```

3.6.2 Description of DMAP Operations for Buckling Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

28. Go to DMAP No. 163 and print error message if no structural elements.

32. EMG generates structural element matrix stiffness and mass tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no stiffness matrix is to be assembled.

36. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no mass matrix is to be assembled.

40. EMA assembles mass matrix $[M_{gg}]$.

43. Go to DMAP No. 47 if no gravity loads and no weight and balance request.

44. Go to DMAP No. 47 if no weight and balance is requested.

45. GPWG generates weight and balance information.

46. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

48. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

50. Go to DMAP No. 53 if no general elements.

51. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

55. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

57. Go to DMAP No. 172 and print error message if no independent degrees of freedom are defined.

61. Go to DMAP No. 63 if no free-body supports.

62. Go to DMAP No. 165 and print error message if free-body supports are present.

64. Go to DMAP No. 69 if general elements present.

65. GPSP determines if possible grid point singularities remain.

67. Go to DMAP No. 69 if no Grid Point Singuarity Table.

68. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

70. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

72. Go to DMAP No. 77 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

73. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \,\vdots\, R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

75. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

78. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

80. Go to DMAP No. 88 if no single-point constraints.

81. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right].$$

84. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

86. Go to DMAP No. 89 if no omitted coordinates.

87. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

90. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

92. SSG1 generates static load vectors $\{P_g\}$.

94. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

96. Go to DMAP No. 99 if no constraints applied.

97. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ -- \\ P_m \end{Bmatrix}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ -- \\ P_s \end{Bmatrix}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ -- \\ P_o \end{Bmatrix} \text{ and } \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} \quad .$$

100. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} \ ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

103. Go to DMAP No. 106 if residual vectors are not to be printed.

104. Print residual vector for independent coordinates (RULV)

105. Print residual vector for omitted coordinates (RUØV).

107. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ \hline u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ \hline Y_s \end{Bmatrix} = \{u_n\},$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ \hline u_m \end{Bmatrix} = \{u_g\},$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

109. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no static solution deformed structure plots are requested.

114. PLØT generates all requested static solution deformed structure and contour plots.

116. PRTMSG prints plotter data, engineering data, and contour data for each static solution deformed plot generated.

118. TA1 generates element tables for use in differential stiffness matrix assembly.

119. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

121. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ if no multipoint constraints.

123. Go to DMAP No. 126 if no multipoint constraints.

124. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction $[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m]$.

127. Equivalence $[K_{nn}^d]$ to $[K_{ff}^d]$ if no single-point constraints.

129. Go to DMAP No. 132 if no single-point constraints.

130. SCE1 partitions out single-point constraints

$$[K_{nn}^d] = \left[\begin{array}{c|c} K_{ff}^d & K_{fs}^d \\ \hline K_{sf}^d & K_{ss}^d \end{array}\right] .$$

133. Equivalence $[K_{ff}^{d}]$ to $[K_{aa}^{d}]$ if no omitted coordinates.

135. Go to DMAP No. 138 if no omitted coordinates.

136. SMP2 partitions constrained differential stiffness matrix

$$[K_{ff}^{d}] = \left[\begin{array}{c|c} \bar{K}_{aa}^{d} & K_{ao}^{d} \\ \hline K_{oa}^{d} & K_{oo}^{d} \end{array}\right]$$

and performs matrix reduction $[K_{aa}^{d}] = [\bar{K}_{aa}^{d}] + [K_{oa}^{d}]^{T}[G_o] + [G_o]^{T}[K_{oa}^{d}] + [G_o]^{T}[K_{oo}^{d}][G_o]$.

141. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

143. Go to DMAP No. 167 and print error message if no Eigenvalue Extraction Data.

146. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell} + \lambda K_{\ell\ell}^{d}]\{u_\ell\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component

149. ØFP formats eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

151. Go to DMAP No.169 and print error message if no eigenvalues found.

152. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\}, \qquad \left\{\begin{array}{c} \phi_a \\ \hline \phi_o \end{array}\right\} = \{\phi_f\},$$

$$\left\{\begin{array}{c} \phi_f \\ \hline \phi_s \end{array}\right\} = \{\phi_n\}, \qquad \{\phi_m\} = [G_m]\{\phi_n\},$$

$$\left\{\begin{array}{c} \phi_n \\ \hline \phi_m \end{array}\right\} = \{\phi_g\}$$

and recovers single point forces of constraint $\{q_s\} = [K_{fs}^{T}]\{\phi_f\}$.

154. SDR2 calculates element forces (ØBEF1) and stresses (ØBES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØBQG1) for output and translation components of the eigenvectors (PPHIG) for the buckling solution.

155. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

157. Go to DMAP No. 161 if no deformed buckling solution structure plots are requested.

158. PLØT generates all requested deformed buckling solution structure and contour plots.

160. PRTMSG prints plotter data, engineering data, and contour data for each deformed buckling solution plot generated.

162. Go to DMAP No. 175 and make normal exit.

164. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

166. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 2 - FREE BØDY-SUPPØRTS NØT ALLØWED.

168. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

170. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUES FØUND.

172. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

174. BUCKLING ANALYSIS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.6.3 Automatic Output for Buckling Analysis

The summary of the eigenvalues associated with the buckling modes and the summary of the eigenvalue analysis performed, as described in the Normal Mode Analysis rigid format, are automatically printed.

3.6.4 Case Control Deck and Parameters for Buckling Analysis

The following items relate to subcase definition and data selection for Buckling Analysis:

1. The Case Control Deck must contain at least two subcases. Subcases beyond the second are used only for output selection.
2. METHØD must appear in the second subcase to select an EIGB card from the Bulk Data Deck.
3. A static loading condition must be defined in the first subcase with a LØAD, TEMPERATURE(LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.
4. An SPC set must be selected above the subcase level, unless all constraints are specified on GRID cards.
5. Output requests that apply only to the solution under static load must be placed in the first subcase.
6. Output requests that apply to the buckling solution only must be placed in the second and succeeding subcases. If only two subcases exist, the output requests in the second subcase will be honored for all buckling modes.
7. Output requests that apply to both the static solution and the buckling modes may be placed above the subcase level.

The following output may be requested for Buckling Analysis:

1. Displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for the static analysis.
2. Forces and stresses in selected elements for the static loading condition.
3. Mode shapes and nonzero components of the single-point forces of constraint at selected grid points for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected buckling modes.

5. Contour plots of stress and displacement for selected buckling modes.

The following parameters are used in Buckling Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

4. COUPMASS - CPBAR, CPROD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.6.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.7 PIECEWISE LINEAR ANALYSIS

3.7.1 DMAP Sequence for Piecewise Linear Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 6

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO     ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    NO.6 PIECEWISE LINEAR STATIC ANALYSIS - SERIES 0 $

   2  FILE     QG1=APPEND/UGV1=APPEND/KGGSUM=SAVE/PGV1=APPEND $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET $

   5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   6  GP2      GEOM2,EQEXIN/ECT $

   7  CHKPNT   ECT $

   8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  10  COND     P1,NOPCDB $

  11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

  12  SAVE     NSIL,JUMPPLOT $

  13  PRTMSG   PLTSETX// $

  14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  16  COND     P1,JUMPPLOT $

  17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  18  SAVE     JUMPPLOT,PLTFLG,PFILE $


  19  PRTMSG   PLOTX1// $

  20  LABEL    P1 $

  21  CHKPNT   PLTPAR,GPSETS,ELSETS $

  22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

  23  SAVE     NOGRAV $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  PARAM    //C,N,AND/V,N,SKPMGG/V,N,NOGRAV/V,Y,GRDPNT $

25  CHKPNT   SLT,GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,ECPT ,GPCT/V,N,LUSET/   V,
             N,NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  PARAM    //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

29  COND     ERROR4,NOELMT $

30  PURGE    GPST/NOSIMP/OGPST/GENEL $

31  CHKPNT   EST,ECPT,GPCT,GEI,GPST,OGPST $

32  COND     LBL1,NOSIMP $

33  SMA1     CSTM,MPT,ECPT,GPCT,DIT/KGGX,,GPST/V,N,NOGENL/V,N,NOK4GG $

34  CHKPNT   GPST,KGGX $

35  COND     LBL1,SKPMGG $

36  SMA2     CSTM,MPT,ECPT,GPCT,DIT/MGG,/V,Y,WTMASS=1.0/V,N,NOMGG/V,N,NOBGG/
             C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,
             CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,
             CPTRBSC $

37  SAVE     NOMGG $

38  CHKPNT   MGG $

39  COND     LBL1,GRDPNT $

40  COND     ERROR3,NOMGG $

41  GPWG     BGPDT,CSTM, EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/V,Y,WTMASS $


42  OFP      OGPWG,,,,,,// $

43  LABEL    LBL1 $

44  PLA1     CSTM,MPT,ECPT,GPCT,DIT,CASECC,EST/KGGXL,ECPTNL,ESTL,ESTNL/V,N,
             KGGLPG/V,N,NPLALIM/V,N,ECPTNLPG/V,N,PLSETNO/V,N,NONLSTR/V,N,
             PLFACT $

45  SAVE     KGGLPG,NPLALIM,ECPTNLPG,PLSETNO,NONLSTR,PLFACT $

46  COND     ERROR1,ECPTNLPG $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
47  PURGE    ONLES,ESTNL1/NONLSTR $

48  CHKPNT   KGGXL,ECPTNL,ESTL,ESTNL,ESTNL1 $

49  PARAM    //C,N,ADD/V,N,ALWAYS/C,N,-1/C,N,0 $

50  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

51  EQUIV    KGGX,KGG/NOGENL/KGGXL,KGGL/NOGENL $

52  CHKPNT   KGG,KGGL $

53  COND     LBL11,NOGENL $

54  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

55  CHKPNT   KGG $

56  SMA3     GEI,KGGXL/KGGL/V,N,LUSET/V,N,NOGENL/V,N,KGGLPG $

57  CHKPNT   KGGL $

58  LABEL    LBL11 $

59  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

60  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

61  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

62  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

63  PURGE    KRR,KLR,QR,DM/REACT/GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,
             KFS,KSS/SINGLE/QG/NOSR $

64  CHKPNT   KRR,KLR,QR,DM,GM,GO,KOO,LOO,PO,UOOV,QG,PS,KFS,KSS,USET,RG,YS,
             RUOV $


65  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,,,MGG,CASECC,DIT/PG1/V,N,   LUSET/C,
             N,1 $

66  CHKPNT   PG1 $

67  EQUIV    PG1,PL/NOSET $

68  CHKPNT   PL $

69  COND     LBL4,GENEL $

70  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
SAVE     NOGPST $
COND     LBL4,NOGPST $
OFP      OGPST,,,,,// $
LABEL    LBL4 $
PARAM    //C,N,ADD/V,N,PLACOUNT/C,N,1/C,N,0 $
EQUIV    KGG,KNN/MPCF1 $
CHKPNT   KNN $
COND     LBL2,MPCF2 $
MCE1     USET,RG/GM $
CHKPNT   GM $
PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
JUMP     LOOPBGN $
------------------------------------------------ Top of DMAP Loop
LABEL    LOOPBGN $
EQUIV    KGG,KNN/MPCF2 $
CHKPNT   KNN $
COND     LBL2,MPCF2 $
MCE2     USET,GM,KGG,,,/KNN,,, $
CHKPNT   KNN $
LABEL    LBL2 $
EQUIV    KNN,KFF/SINGLE $

CHKPNT   KFF $
COND     LBL3,SINGLE $
SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $
CHKPNT   KFS,KSS,KFF $
LABEL    LBL3 $
EQUIV    KFF,KAA/OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 97  CHKPNT   KAA $
 98  COND     LBL5,OMIT $
 99  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
100  CHKPNT   GO,KAA,KOO,LOO $
101  LABEL    LBL5 $
102  EQUIV    KAA,KLL/REACT $
103  CHKPNT   KLL $
104  COND     LBL6,REACT $
105  RBMG1    USET,KAA,/KLL,KLR,KRR,,, $
106  CHKPNT   KLL,KLR,KRR $
107  LABEL    LBL6 $
108  DECOMP   KLL/LLL,/C,N,1/C,N,O/V,N,MINDIAGK/V,N,DETKLLXX/V,N,IDETKLLX/ V,
              N,SINGKLLX $
109  SAVE     SINGKLLX $
110  COND     LOOPENDA,SINGKLLX $
111  CHKPNT   LLL $
112  COND     LBL7,REACT $
113  RBMG3    LLL,KLR,KRR/DM $
114  CHKPNT   DM $
115  LABEL    LBL7 $
116  ADD      PG1,/PG/V,N,PLFACT $

117  CHKPNT   PG $
118  COND     LBL10,NOSET $
119  SSG2     USET,GM,YS,KFS,GO,DM,PG/QR,PO,PS,PL $
120  CHKPNT   QR,PO,PS,PL $
121  LABEL    LBL10 $
122  SSG3     LLL,KLL,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                V,N,PLACOUNT/V,N,EPSI $

123  SAVE       EPSI $

124  CHKPNT     ULV,UOOV,RULV,RUOV $

125  COND       LBL9,IRES $

126  MATGPR     GPL,USET,SIL,RULV//C,N,L $

127  MATGPR     GPL,USET,SIL,RUOV//C,N,O $

128  LABEL      LBL9 $

129  SDR1       USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,QR/DELTAUGV,DELTAPG,
                DELTAQG/C,N,1/C,N,STATICS $

130  CHKPNT     DELTAUGV,DELTAPG,DELTAQG $

131  PLA2       DELTAUGV,DELTAPG,DELTAQG/UGV1,PGV1,QG1/V,N,PLACOUNT $

132  SAVE       PLACOUNT $

133  CHKPNT     UGV1,QG1,PGV1 $

134  EQUIV      ESTNL,ESTNL1/NEVER/ECPTNL,ECPTNL1/NEVER $

135  COND       PLALBL2A,NONLSTR $

136  PLA3       CSTM,MPT,DIT,DELTAUGV,ESTNL,CASECC/ONLES,ESTNL1/V,N,PLACOUNT/
                V,N,PLSETNO $

137  CHKPNT     ESTNL1 $

138  OFP        ONLES,,,,,//V,N,CARDNO $

139  SAVE       CARDNO $

140  LABEL      PLALBL2A $

141  PARAM      //C,N,SUB/V,N,DIFF/V,N,NPLALIM/V,N,PLACOUNT $


142  COND       LOOPEND,DIFF $

143  PLA4       CSTM,MPT,ECPTNL,GPCT,DIT,DELTAUGV/KGGNL,ECPTNL1/V,N,PLACOUNT/V,
                N,PLSETNO/V,N,PLFACT $

144  SAVE       PLACOUNT,PLSETNO,PLFACT $

145  CHKPNT     KGGNL,ECPTNL1 $

146  EQUIV      KGGNL,KGGSUM/KGGLPG $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
147  CHKPNT   KGGSUM $
148  COND     PLALBL3,KGGLPG $
149  ADD      KGGNL,KGGL/KGGSUM $
150  CHKPNT   KGGSUM $
151  LABEL    PLALBL3 $
152  EQUIV    KGGSUM,KGG/ALWAYS $
153  CHKPNT   KGG $
154  EQUIV    ESTNL1,ESTNL/ALWAYS/ECPTNL1,ECPTNL/ALWAYS $
155  CHKPNT   ESTNL,ECPTNL $
156  COND     PLALBL4,ALWAYS $
157  PLA2     KGGSUM,KGG,/,,/C,N,0 $
158  PLA2     ESTNL1,ECPTNL1,/,,/C,N,0 $
159  LABEL    PLALBL4 $
160  REPT     LOOPBGN,360 $
------------------------------------------------ Bottom of DMAP Loop
161  JUMP     ERROR2 $
162  LABEL    LOOPENDA $
163  PRTPARM  //C,N,+5/C,N,PLA $
164  LABEL    LOOPEND $
165  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG1,UGV1,ESTL,,
              PGV1/OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,PLA $
166  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

167  SAVE     CARDNO $
168  COND     P2,JUMPPLOT $
169  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,ECPT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
170  SAVE     PFILE $
171  PRTMSG   PLOTX2// $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 6

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
172  LABEL    P2 $
173  JUMP     FINIS $
174  LABEL    ERROR1 $
175  PRTPARM  //C,N,-1/C,N,PLA $
176  LABEL    ERROR2 $
177  PRTPARM  //C,N,-2/C,N,PLA $
178  LABEL    ERROR3 $
179  PRTPARM  //C,N,-3/C,N,PLA $
180  LABEL    ERROR4 $
181  PRTPARM  //C,N,-4/C,N,PLA $
182  LABEL    FINIS $
183  END      $
```

3.7.2 Description of DMAP Operations for Piecewise Linear Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

29. Go to DMAP No. 180 and print error message if no elements have been defined.

32. Go to DMAP No. 35 if there are no structural elements.

33. SMA1 generates stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

35. Go to DMAP No. 43 if no mass matrix is to be generated.

36. SMA2 generates mass matrix $[M_{gg}]$.

39. Go to DMAP No. 43 if no weight and balance is requested.

40. Go to DMAP No. 178 and print error message if no mass matrix exists.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

44. PLA1 extracts the linear terms from $[K^x_{gg}]$ to give $[K^{x\ell}_{gg}]$, extracts the nonlinear entries from the Element Connection and Properties Table to give ECPTNL, and separates the linear and nonlinear entries in the Element Summary Table to give ESTL and ESTNL.

46. Go to DMAP No. 174 and print error message if no elements have a stress dependent modulus of elasticity.

51. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ and $[K^{x\ell}_{gg}]$ to $[K^{\ell}_{gg}]$ if no general elements.

53. Go to DMAP No. 58 if no general elements.

54. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

56. SMA3 adds general elements to $[K^{x\ell}_{gg}]$ to obtain stiffness matrix of linear elements $[K^{\ell}_{gg}]$

60. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

65. SSG1 generates total static load vector $\{P_g^1\}$.

67. Equivalence $\{P_g^1\}$ to $\{P_\ell\}$ if no constraints applied.

69. Go to DMAP No. 74 if general elements present.

70. GPSP determines if possible grid point singularities remain.

72. Go to DMAP No. 74 if no Grid Point Singularity Table.

73. OFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 89 if no multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

82. Beginning of loop for Piecewise Linear Analysis.

84. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

86. Go to DMAP No. 91 if no multipoint constraints.

87. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

90. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

92. Go to DMAP No. 95 if no single-point constraints.

93. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

96. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

98. Go to DMAP No. 101 if no omitted coordinates.

99. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right],$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$ and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

102. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

104. Go to DMAP No. 107 if no free-body supports.

105. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right]$$

108. DECØMP decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

110. Go to DMAP No. 162 if stiffness matrix $[K_{\ell\ell}]$ is singular (i.e., local plasticity).

112. Go to DMAP No. 115 if no free-body supports.

113. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||}$$

116. ADD multiplies total load vector $\{P_g^1\}$ by factor, PLFACT, and adds it to nothing to obtain applied load vector $\{P_g\}$ for current loop.

118. Go to DMAP No. 121 if no constraints applied.

119. SSG2 applies constraints to static load vector for current loop.

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hline P_m \end{array}\right\}, \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\},$$

$$\{P_n\} = \left\{\begin{array}{c} \bar{P}_f \\ \hline P_s \end{array}\right\}, \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\},$$

$$\{P_f\} = \left\{\begin{array}{c} \bar{P}_a \\ \hline P_o \end{array}\right\}, \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\},$$

$$\{P_a\} = \left\{\begin{array}{c} P_\ell \\ \hline P_r \end{array}\right\}$$

and calculates incremental determinate forces of reaction for current loop

$$\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}.$$

122. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} \ ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\},$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} \ .$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}} \qquad .$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\},$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} \qquad .$$

125. Go to DMAP No. 128 if residual vectors are not to be printed.

126. Print residual vector for independent coordinates (RULV)

127. Print residual vector for omitted coordinates (RUØV).

129. SDR1 recovers dependent incremental displacements for current loop

$$\left\{\begin{array}{c} u_\ell \\ \hline u_r \end{array}\right\} = \{u_a\}, \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\},$$

$$\left\{\begin{array}{c} u_a \\ \hline u_o \end{array}\right\} = \{u_f\} \ , \qquad \left\{\begin{array}{c} u_f \\ \hline Y_s \end{array}\right\} = \{u_n\} \ ,$$

$$\{u_m\} = [G_m]\{u_n\}, \qquad \left\{\begin{array}{c} u_n \\ \hline u_m \end{array}\right\} = \{u_g\} \ .$$

and recovers incremental single-point forces of constraint for current loop

$$\{\delta q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} \ .$$

131. PLA2 adds the incremental displacement vector (DELTAUGV) and the incremental single-point forces of constraint vector (DELTAQG) for the current loop to the accumulated sum of these vectors (DELTAPG).

$$\{u_{g_{i+1}}\} = \{\delta u_{g_i}\} + \{u_{g_i}\} \quad \text{and}$$

$$\{q_{g_{i+1}}\} = \{\delta q_{g_i}\} + \{q_{g_i}\} \quad .$$

134. Allocate separate files for ESTNL and ESTNL1 and for ECPTNL and ECPTNL1.

135. Go to DMAP No. 140 if no stress output requested for nonlinear elements.

136. PLA3 calculates incremental stresses in nonlinear elements (ØNLES) for which an output request has been made and updates the accumulated stresses (ESTNL1) in these elements.

138. ØFP formats the accumulated stresses in nonlinear elements prepared by PLA3 and places them on the system output file for printing.

142. Go to DMAP No. 164 if all loading increments have been completed.

143. PLA4 generates stiffness matrix for nonlinear elements $[K_{gg}^{n\ell}]$ and updates stress information.

146. Equivalence $[K_{gg}^{n\ell}]$ to $[K_{gg}]$ if all elements are nonlinear.

148. Go to DMAP No. 151 if all elements are nonlinear.

149. Add stiffness matrix for nonlinear elements to stiffness matrix for linear elements

$$[K_{gg}^{n\ell}] + [K_{gg}^{\ell}] = [K_{gg}^{sum}]$$

152. Equivalence $[K_{gg}^{sum}]$ to $[K_{gg}]$ for next pass through loop.

154. Equivalence existing element tables to updated tables for next pass through loop.

156. Go to DMAP No. 159 because the next two instructions are never executed.

160. Go to DMAP No. 83 if additional load increments need to be processed.

161. Go to DMAP No. 176 and print error message if more than 360 loops.

162. End of loop for Piecewise Linear Analysis when local plasticity occurs in $K_{\ell\ell}$.

163. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

164. End of loop for Piecewise Linear Anslysis.

165. SDR2 calculates element forces (ØEF1) and stresses for linear elements (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

166. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

168. Go to DMAP No. 172 if no deformed structure plots are requested.

169. PLØT generates all requested deformed structure and contour plots.

171. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

173. Go to DMAP No. 182 and make normal exit.

175. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

177. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

179. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

181. PIECEWISE LINEAR ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

3.7.3 Case Control Deck and Parameters for Piecewise Linear Analysis

The following items relate to subcase definition and data selection for Piecewise Linear Analysis:

1. The Case Control Deck must contain one and only one subcase.
2. A static loading condition must be defined with a LØAD selection.
3. An SPC set must be selected unless all constraints are specified on GRID cards.
4. PLCØEFFICIENT must appear either to select a PLFACT set from the Bulk Data Deck or to explicitly select the default value of unity.

The following output may be requested for Piecewise Linear Analysis:

1. Accumulated sums of displacements and nonzero components of the static loads and single-point forces of constraint at selected grid points for each load increment.
2. Stresses in selected elements. If an element is composed of a nonlinear material the accumulated stress will be output for each load increment. Stresses in linear elements are only calculated for the total load.
3. Undeformed plot of the structural model and deformed plots for each load increment.
4. Contour plots of stress and displacement for each load increment.

The following parameters are used in Piecewise Linear Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.
2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in SMA2.
3. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.
4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.8 DIRECT COMPLEX EIGENVALUE ANALYSIS

3.8.1 DMAP Sequence for Direct Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO     ERR=2   NOLIST   NODECK   NOREF   NOOSCAR

   1  BEGIN     NO.7 DIRECT COMPLEX EIGENVALUE ANALYSIS - SERIES 0 $

   2  FILE      KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

   3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

   4  SAVE      LUSET,NOGPDT $

   5  PURGE     USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,EST,ECT,PLTSETX,PLTPAR,GPSETS,
                ELSETS/NOGPDT $

   6  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,EST,
                ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

   7  COND      LBL5,NOGPDT $

   8  GP2       GEOM2,EQEXIN/ECT $

   9  CHKPNT    ECT $

  10  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  11  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  12  COND      P1,NOPCDB $

  13  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

  14  SAVE      NSIL,JUMPPLOT $

  15  PRTMSG    PLTSETX// $

  16  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  17  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


  18  COND      P1,JUMPPLOT $

  19  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  20  SAVE      PFILE $

  21  PRTMSG    PLOTX1// $

  22  LABEL     P1 $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  CHKPNT  PLTPAR,GPSETS,ELSETS $

24  GP3     GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

25  CHKPNT  GPTT $

26  TA1     ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
            NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27  SAVE    NOSIMP,NOGENL,GENEL $

28  PURGE   K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
            KGGX/NOSIMP / OGPST/GENEL $

29  CHKPNT  EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
            MNN,MFF,MAA,BNN,BFF,BAA $

30  COND    LBL1,NOSIMP $

31  PARAM   //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  PARAM   //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33  PARAM   //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34  PARAM   //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35  EMG     EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/V,N,
            NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
            CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
            CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

36  SAVE    NOKGGX,NOMGG,NOBGG,NOK4GG $

37  CHKPNT  KELM,KDICT,MELM,MDICT,BELM,BDICT $

38  COND    LBLKGGX,NOKGGX $

39  EMA     GPECT,KDICT,KELM/KGGX,GPST $


40  CHKPNT  KGGX,GPST $

41  LABEL   LBLKGGX $

42  COND    LBLMGG,NOMGG $

43  EMA     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44  CHKPNT  MGG $

45  LABEL   LBLMGG $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
46  COND     LBLBGG,NOBGG $
47  EMA      GPECT,BDICT,BELM/BGG, $
48  CHKPNT   BGG $
49  LABEL    LBLBGG $
50  COND     LBLK4GG,NOK4GG $
51  EMA      GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT   K4GG $
53  LABEL    LBLK4GG $
54  PURGE    MNN,MFF,MAA/NOMGG $
55  PURGE    BNN,BFF,BAA/NOBGG $
56  CHKPNT   MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57  COND     LBL1,GRDPNT $
58  COND     ERROR3,NOMGG $
59  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $
60  OFP      OGPWG,,,,,// $
61  LABEL    LBL1 $
62  EQUIV    KGGX,KGG/NOGENL $
63  CHKPNT   KGG $
64  COND     LBL11,NOGENL $
65  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

66  CHKPNT   KGG $
67  LABEL    LBL11 $
68  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1/   C,Y,SUBID $
70  SAVE     MPCF1,MPCF2,SINGLE,OMIT,NSKIP,NOSET,REACT,REPEAT,NOL,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,QPC/SINGLE $
72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,QPC $
73  COND     LBL4,GENEL $
74  COND     LBL4,NOSIMP $
75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76  SAVE     NOGPST $
77  COND     LBL4,NOGPST $
78  OFP      OGPST,,,,,// $
79  LABEL    LBL4 $
80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
81  CHKPNT   KNN,MNN,BNN,K4NN $
82  COND     LBL2,MPCF2 $
83  MCE1     USET,RG/GM $
84  CHKPNT   GM $
85  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
86  CHKPNT   KNN,MNN,BNN,K4NN $
87  LABEL    LBL2 $
88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
89  CHKPNT   KFF,MFF,BFF,K4FF $
90  COND     LBL3,SINGLE $

91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $
92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $
93  LABEL    LBL3 $
94  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT/BFF,BAA/OMIT/K4FF,K4AA/OMIT $
95  CHKPNT   KAA,MAA,BAA,K4AA $
96  COND     LBL5,OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 97  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
 98  CHKPNT   GO,KAA $
 99  COND     LBLM,NOMGG $
100  SMP2     USET,GO,MFF/MAA $
101  CHKPNT   MAA $
102  LABEL    LBLM $
103  COND     LBLB,NOBGG $
104  SMP2     USET,GO,BFF/BAA $
105  CHKPNT   BAA $
106  LABEL    LBLB $
107  COND     LBL5,NOK4GG $
108  SMP2     USET,GO,K4FF/K4AA $
109  CHKPNT   K4AA $
110  LABEL    LBL5 $
111  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/
              V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $
112  SAVE     LUSETD,NOUE $
113  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
114  CHKPNT   USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $
115  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

116  PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $
117  BMG      MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
              MFACT $
118  SAVE     MFACT,NOKBFL,NOABFL $
119  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $
120  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $
121  COND     LBLFL3,NOFL $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  MTRXIN   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $

123  SAVE     NOABFL,NOKBFL $

124  LABEL    LBLFL3 $

125  CHKPNT   ABFL,KBFL $

126  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

127  JUMP     LBL13 $
---------------------------------------------------- Top of DMAP Loop
128  LABEL    LBL13 $

129  PURGE    PHID,CLAMA,OPHID,OQPC1,OCPHIP,OESC1,OEFC1,CPHIP,QPC,  K2PP,
              M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

130  CASE     CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

131  SAVE     REPEATE,NOLOOP $

132  CHKPNT   CASEXX $

133  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

134  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

135  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

136  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

137  EQUIV    M2DPP,M2PP/NOABFL $

138  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

139  COND     LBLFL2,NOABFL $

140  TRNSP    ABFL/ABFLT $


141  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

142  LABEL    LBLFL2 $

143  PARAM    //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

144  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

145  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

146  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
147  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
              BDD/BDEBA $

148  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

149  COND     LBL18,NOGPDT $

150  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,CMPLEV/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/C,
              N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,
              N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,N,
              -1 $

151  LABEL    LBL18 $

152  EQUIV    B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

153  CHKPNT   KDD,BDD,MDD,GOD,GMD $

154  COND     ERROR1,NOEED $

155  CEAD     KDD,BDD,MDD,EED,CASEXX/PHID,CLAMA,OCEIGS/V,N,EIGVS $

156  SAVE     EIGVS $

157  CHKPNT   PHID,CLAMA,OCEIGS $

158  OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $

159  SAVE     CARDNO $

160  COND     LBL16,EIGVS $

161  VDR      CASEXX,EQDYN,USETD,PHID,CLAMA,,/OPHID,/C,N,CEIGN/C,N,DIRECT/C,
              N,0/V,N,NOD/V,N,NOP/C,N,0 $

162  SAVE     NOD,NOP $

163  COND     LBL15,NOD $


164  OFP      OPHID,,,,,//V,N,CARDNO $

165  SAVE     CARDNO $

166  LABEL    LBL15 $

167  COND     LBL16,NOP $

168  EQUIV    PHID,CPHIP/NOA $

169  COND     LBL17,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 7

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
170  SDR1     USETD,, PHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1/C,N,DYNAMICS $
171  LABEL    LBL17 $
172  CHKPNT   CPHIP,QPC $
173  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,,/,OQPC1,
              OCPHIP,OESC1,OEFC1,/C,N,CEIG $
174  OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $
175  SAVE     CARDNO $
176  LABEL    LBL16 $
177  COND     FINIS,REPEATE $
178  REPT     LBL13,100 $
-------------------------------------------------------- Bottom of DMAP Loop
179  JUMP     ERROR2 $
180  JUMP     FINIS $
181  LABEL    ERROR2 $
182  PRTPARM  //C,N,-2/C,N,DIRCEAD $
183  LABEL    ERROR1 $
184  PRTPARM  //C,N,-1/C,N,DIRCEAD $
185  LABEL    ERROR3 $
186  PRTPARM  //C,N,-3/C,N,DIRCEAD $
187  LABEL    FINIS $
188  END      $
```

3.8.2 Description of DMAP Operations for Direct Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

7. Go to DMAP No. 110 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix is to be assembled.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.

51. EMA assembles structural damping matrix $[K_{gg}^{4}]$.

57. Go to DMAP No. 61 if no weight and balance is requested.

58. Go to DMAP No. 185 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats the weight and balance information prepared by GPWG and places it on the system output file for printing.

62. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no structural elements.

78. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \,\vdots\, R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G^T_m][K_{mn}] + [K^T_{mn}][G_m] + [G^T_m][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G^T_m][M_{mn}] + [M^T_{mn}][G_m] + [G^T_m][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G^T_m][B_{mn}] + [B^T_{mn}][G_m] + [G^T_m][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G^T_m][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G^T_m][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$, $[M_{ff}]$ to $[M_{aa}]$, $[B_{ff}]$ to $[B_{aa}]$ and $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

96. Go to DMAP No. 110 if no omitted coordinates.

97. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1} [K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

99. Go to DMAP No.102 if no mass matrix.

100. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G^T_o][M_{oo}][G_o]$$

103. Go to DMAP No.106 if no viscous damping matrix.

104. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

107. Go to DMAP No.110 if no structural damping matrix.

108. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

111. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

113. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

117. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

121. Go to DMAP No. 124 if no fluid structure interface is defined.

122. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

127. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

128. Beginning of loop for additional sets of direct input matrices.

130. CASE extracts user requests from CASECC for current loop.

133. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^2_{pp}]$.

137. Equivalence $[M^{2d}_{pp}]$ to $[M^2_{pp}]$ if no $[A_{b,f\ell}]$.

138. ADD5 adds $[K_{b,f\ell}]$ and $[K^{2d}_{pp}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K^2_{pp}]$.

139. Go to DMAP No. 142 if no $[A_{b,f\ell}]$.

140. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

141. ADD assembles input matrix $[M^2_{pp}] = MFACT\ [A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

147. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

149. Go to DMAP No. 151 if only extra points defined.

150. GKAD assembles stiffness, mass, and damping matrices for use in Direct Complex Eigenvalue Analysis

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}],$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \text{ and}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}].$$

Direct input matrices may be complex.

152. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

154. Go to DMAP No. 183 and print error message if no Eigenvalue Extraction Data.

155. CEAD extracts complex eigenvalues from the equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

158. ØFP formats the summary of complex eigenvalues (CLAMA) and summary of eigenvalue extraction information (ØCEIGS) prepared by CEAD and places them on the system output file for printing.

160. Go to DMAP No. 176 if no eigenvalues found.

161. VDR prepares eigenvectors for output, using only the independent degrees of freedom.

163. Go to DMAP No. 166 if no output request for the independent degrees of freedom.

164. ØFP formats the eigenvectors for independent degrees of freedom prepared by VDR and places them on the system output file for printing.

167. Go to DMAP No. 176 if no output request involving dependent degrees of freedom or forces and stresses.

168. Equivalence $\{\phi_d\}$ to $\{\phi_p\}$ if no constraints applied.

169. Go to DMAP No. 171 if no constraints applied.

170. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \ , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi_f + \phi_e\} \ ,$$

$$\left\{\begin{array}{c}\phi_f + \phi_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + \phi_e\} \ , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \ ,$$

$$\left\{\begin{array}{c}\phi_n + \phi_e \\ \hline d_m\end{array}\right\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}^T]\{\phi_f\} \ .$$

173. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares eigenvectors (ØCPHIP) and single-point forces of constraint (ØQPC1) for output.

174. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

177. Go to DMAP No. 187 if no additional sets of direct input matrices need to be processed.

178. Go to DMAP No. 128 if additional sets of direct input matrices need to be processed.

179. Go to DMAP No. 181 and print error message if more than 100 loops.

180. Go to DMAP No. 187 and make normal exit.

182. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

184. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

186. DIRECT CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.8.3 Automatic Output for Direct Complex Eigenvalue Analysis

Each complex eigenvalue is identified with a root number determined by sorting the complex eigenvalues according to the magnitude of the imaginary part, with positive values considered as a group ahead of all negative values. The following summary of the complex eigenvalues extracted is automatically printed for each set of direct input matrices:

1. Root Number
2. Extraction Order
3. Real and Imaginary Parts of the Eigenvalue
4. The coefficients f_j (frequency) and g_j (damping coefficient) in the following representation of the eigenvalue

$$p_j = 2\pi f_j(i - \frac{1}{2} g_j)$$

The following summary of the eigenvalue analysis performed using the Determinant method is automatically printed for each set of direct input matrices:

1. Number of eigenvalues extracted
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Number of predictions outside region.
8. Reason for termination:
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the regions specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
9. Swept determinant functions for each starting point.

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed for each region specified:

1. Number of eigenvalues extracted.

2. Number of starting points used.

3. Number of starting point moves.

4. Number of triangular decompositions.

5. Number of vector iterations.

6. Reason for termination.

   (1) Two consecutive singularities encountered while performing triangular decomposition.

   (2) Four starting point moves while tracking a single root.

   (3) All eigenvalues found in the region specified.

   (4) Three times the number of roots estimated in the region have been extracted.

   (5) All eigenvalues that exist in the problem have been found.

   (6) The number of roots desired have been found.

   (7) One or more eigenvalues have been found outside the region specified.

   (8) Insufficient time to find another root.

   (9) Unable to converge.

The following summary of the eigenvalue analysis performed, using the complex Tridiagonal Reduction (FEER) method, is automatically printed:

1. Number of eigenvalues extracted.

2. Number of starting points used.

   This corresponds to the total number of random starting and restart vectors used by the complex FEER process for all neighborhoods.

3. Number of starting point moves.

   Not used in FEER (set equal to zero).

4. Number of triangular decompositions.

   Always equal to the number of points of interest (neighborhoods) in the complex plane processed by FEER, since ordinarily only one triangular decomposition is required by FEER

for each point of interest, unless the dynamic matrix is singular at a given point of interest, in which case an additional decomposition is required (obtained by moving the point of interest slightly).

5. Total number of vector iterations.

   The total number of reorthogonalizations of all the trial vectors employed.

6. Reason for termination.

   (0) All, or more solutions than the number requested by the user, have been determined (normal termination).

   (1) All neighborhoods have been processed, but FEER has not obtained the desired number of roots in each neighborhood, possibly because they have already been found in other neighborhoods.

   (2) Abnormal termination - either no roots found or none pass the FEER error test.

3.8.4 Case Control Deck and Parameters for Direct Complex Eigenvalue Analysis

The following items relate to subcase definition and data selections for Direct Complex Eigenvalue Analysis.

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP).

2. Multiple subcases for each set of direct input matrices are used only to control output requests. A single subcase for each set of direct input matrices is sufficient if the same output is desired for all modes. If consecutive multiple subcases are present for a single set of direct input matrices, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

3. CMETHØD must be used to select an EIGC card from the Bulk Data Deck for each set of direct input matrices.

4. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and either CMETHØD must be changed to select an EIGC card that reflects any complex eigenvalues found in the previous execution or EIGP cards must be used to insert poles for previously found eigenvalues. Otherwise, the previously found eigenvalues will be extracted again.

5. Constraints must be defined above the subcase level.

The following printed output, sorted by complex eigenvalue root number (SØRT1), may be requested for any complex eigenvalue extracted, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead):

1. The eigenvector for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements.

In addition an undeformed plot of the structural model may be requested.

The following parameters are used in Direct Complex Eigenvalue Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.9 DIRECT FREQUENCY AND RANDOM RESPONSE

3.9.1 DMAP Sequence for Direct Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 8

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO     ERR=2   NOLIST   NODECK   NOREF   NOOSCAR

    1  BEGIN    NO.8 DIRECT FREQUENCY RESPONSE ANALYSIS - SERIES 0 $

    2  FILE     KGGX=TAPE/ KGG=TAPE/ GOD=SAVE/ GMD=SAVE $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET,NOGPDT $

    5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,
                GPSETS,ELSETS/NOGPDT $

    6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
                KFS,PSF,QPC,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

    7  COND     LBL5,NOGPDT $

    8  GP2      GEOM2,EQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     P1,NOPCDB $

   13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   14  SAVE     NSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


   18  COND     P1,JUMPPLOT $

   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     PFILE $

   21  PRTMSG   PLOTX1//$

   22  LABEL    P1 $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  CHKPNT   PLTPAR,GPSETS,ELSETS $

24  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

25  CHKPNT   GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  PURGE    K4GG,GPST,OGPST,MGG,BGG,K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,BAA,
             KGGX/NOSIMP/OGPST/GENEL $

29  CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
             MNN,MFF,MAA,BNN,BFF,BAA $

30  COND     LBL1,NOSIMP $

31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33  PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34  PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/   V,
             N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
             CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
             CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

36  SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $

37  CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $

38  COND     LBLKGGX,NOKGGX $

39  EMA      GPECT,KDICT,KELM/KGGX,GPST $


40  CHKPNT   KGGX,GPST $

41  LABEL    LBLKGGX $

42  COND     LBLMGG,NOMGG $

43  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44  CHKPNT   MGG $

45  LABEL    LBLMGG $
```

```
RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

46  COND      LBLBGG,NOBGG $
47  EMA       GPECT,BDICT,BELM/BGG, $
48  CHKPNT    BGG $
49  LABEL     LBLBGG $
50  COND      LBLK4GG,NOK4GG $
51  EMA       GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT    K4GG $
53  LABEL     LBLK4GG $
54  PURGE     MNN,MFF,MAA/NOMGG $
55  PURGE     BNN,BFF,BAA/NOBGG $
56  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57  COND      LBL1,GRDPNT $
58  COND      ERROR4,NOMGG $
59  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
60  OFP       OGPWG,,,,,// $
61  LABEL     LBL1 $
62  EQUIV     KGGX,KGG/NOGENL $
63  CHKPNT    KGG $
64  COND      LBL11,NOGENL $
65  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

66  CHKPNT    KGG $
67  LABEL     LBL11 $
68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
70  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF,QPC/SINGLE $
CHKPNT   GM,GMD,RG,GO,GOD,KFS,PSF,QPC,USET $
COND     LBL4,GENEL $
COND     LBL4,NOSIMP $
GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
SAVE     NOGPST $
COND     LBL4,NOGPST $
OFP      OGPST,,,,,// $
LABEL    LBL4 $
EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
CHKPNT   KNN,MNN,BNN,K4NN $
COND     LBL2,MPCF1 $
MCE1     USET,RG/GM $
CHKPNT   GM $
MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
CHKPNT   KNN,MNN,BNN,K4NN $
LABEL    LBL2 $
EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
CHKPNT   KFF,MFF,BFF,K4FF $
COND     LBL3,SINGLE $

SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS,,MFF,BFF,K4FF $
CHKPNT   KFS,KFF,MFF,BFF,K4FF $
LABEL    LBL3 $
EQUIV    KFF,KAA/OMIT $
EQUIV    MFF,MAA/OMIT $
EQUIV    BFF,BAA/OMIT $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 97  EQUIV    K4FF,K4AA/OMIT $
 98  CHKPNT   KAA,MAA,BAA,K4AA $
 99  COND     LBL5,OMIT $
100  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
101  CHKPNT   GO,KAA $
102  COND     LBLM,NOMGG $
103  SMP2     USET,GO,MFF/MAA $
104  CHKPNT   MAA $
105  LABEL    LBLM $
106  COND     LBLB,NOBGG $
107  SMP2     USET,GO,BFF/BAA $
108  CHKPNT   BAA $
109  LABEL    LBLB $
110  COND     LBL5,NOK4GG $
111  SMP2     USET,GO,K4FF/K4AA $
112  CHKPNT   K4AA $
113  LABEL    LBL5 $
114  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,,
              EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,
              NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
115  SAVE     LUSETD,NOUE,NODLT,NOFRL,NOPSDL $

116  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
117  CHKPNT   USETD,EQDYN,TFPOOL,DLT,FRL,GOD,GMD,SILD,PSDL,GPLD $
118  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $
119  PARAM    //C,N,MPY/V,N,REPEATF/C,N,-1/C,N,1 $
120  EMG      MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
              MFACT $
121  SAVE     MFACT,NOKBFL,NOABFL $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  PARAM    //C,N,AND/V,N,NOFL/V,N,NOABFL/V,N,NOKBFL $

123  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $

124  COND     LBLFL3,NOFL $

125  MTRXIN,  ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $

126  SAVE     NOABFL,NOKBFL $

127  LABEL    LBLFL3 $

128  CHKPNT   ABFL,KBFL $

129  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

130  JUMP     LBL13 $
----------------------------------------------- Top of DMAP Loop
131  LABEL    LBL13 $

132  PURGE    OUDVC1,OUDVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
              OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,   K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD/NEVER $

133  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

134  SAVE     REPEATF,NOLOOP $

135  CHKPNT   CASEXX $

136  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

137  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

138  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

139  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $


140  EQUIV    M2DPP,M2PP/NOABFL $

141  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

142  COND     LBLFL2,NOABFL $

143  TRNSP    ABFL/ABFLT $

144  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

145  LABEL    LBLFL2 $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
146  PARAM    //C,N,AND/V,N,BDEBA/V,N,NOUE/V,N,NOB2PP $

147  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $

148  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

149  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

150  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/BAA,
              BDD/BDEBA $

151  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,BDD,MDD $

152  COND     LBL18,NOGPDT $

153  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,FREQRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,N,0.0/C,N,0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/
              V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,KDEK2/C,
              N,-1 $

154  LABEL    LBL18 $

155  EQUIV    B2DD,BDD/NOBGG/ M2DD,MDD/NOSIMP/ K2DD,KDD/KDEK2 $

156  CHKPNT   KDD,BDD,MDD,GMD,GOD $

157  COND     ERROR1,NOFRL $

158  COND     ERROR2,NODLT $

159  FRRD     CASEXX,USETD,DLT,FRL,GMD,GOD,KDD,BDD,MDD,,DIT/UDVF,PSF,PDF,PPF/
              C,N,DISP/C,N,DIRECT/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/
              V,N,NONCUP/V,N,FRQSET $

160  EQUIV    PPF,PDF/NOSET $

161  CHKPNT   PSF,PPF,UDVF,PDF $

162  VDR      CASEXX,EQDYN,USETD,UDVF,PPF,XYCDB,/OUDVC1,/C,N,FREQRESP/C,N,

              DIRECT/V,N,NOSORT2/V,N,NOD/V,N,NOP/C,N,0 $

163  SAVE     NOD,NOP,NOSORT2 $

164  COND     LBL15,NOD $

165  COND     LBL15A,NOSORT2 $

166  CHKPNT   OUDVC1 $

167  SDR3     OUDVC1,,,,,/OUDVC2,,,,, $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
168  OFP     OUDVC2,,,,,//V,N,CARDNO $

169  SAVE    CARDNO $

170  CHKPNT  OUDVC2 $

171  XYTRAN  XYCDB,OUDVC2,,,,/XYPLTFA/C,N,FREQ/C,N,DSET/V,N,PFILE/V,N,
             CARDNO $

172  SAVE    PFILE,CARDNO $

173  XYPLOT  XYPLTFA// $

174  JUMP    LBL15 $

175  LABEL   LBL15A $

176  OFP     OUDVC1,,,,,//V,N,CARDNO $

177  SAVE    CARDNO $

178  LABEL   LBL15 $

179  COND    LBL16,NOP $

180  EQUIV   UDVF,UPVC/NOA $

181  COND    LBL19,NOA $

182  SDR1    USETD,,UDVF,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

183  LABEL   LBL19 $

184  CHKPNT  UPVC,QPC $

185  SDR2    CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,PPF,QPC,UPVC,EST,XYCDB,PPF/
             OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/C,N,FREQRESP/V,N,NOSORT2 $

186  SAVE    NOSORT2 $


187  COND    LBL17,NOSORT2 $

188  SDR3    OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
             OEFC2, $

189  CHKPNT  OPPC2,OQPC2,OUPVC2,OESC2,OEFC2 $

190  OFP     OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

191  SAVE    CARDNO $

192  XYTRAN  XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 8

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                 V,N,PFILE/V,N,CARDNO $

193   SAVE       PFILE,CARDNO $

194   XYPLOT     XYPLTF// $

195   COND       LBL16,NOPSDL $

196   RANDOM     XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
                 V,N,NORD $

197   SAVE       NORD $

198   CHKPNT     PSDF,AUTO $

199   COND       LBL16,NORD $

200   XYTRAN     XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
                 CARDNO $

201   SAVE       PFILE,CARDNO $

202   XYPLOT     XYPLTR// $

203   JUMP       LBL16 $

204   LABEL      LBL17 $

205   OFP        OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $

206   SAVE       CARDNO $

207   LABEL      LBL16 $

208   COND       FINIS,REPEATF $

209   REPT       LBL13,100 $
---------------------------------------------------------- Bottom of DMAP Loop
210   JUMP       ERROR3 $

211   JUMP       FINIS $


212   LABEL      ERROR3 $

213   PRTPARM    //C,N,-3/C,N,DIRFRRD $

214   LABEL      ERROR2 $

215   PRTPARM    //C,N,-2/C,N,DIRFRRD $

216   LABEL      ERROR1 $
```

```
RIGID FORMAT DMAP LISTING
SERIES B

DISPLACEMENT APPROACH, RIGID FORMAT 8

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


217  PRTPARM  //C,N,-1/C,N,DIRFRRD $

218  LABEL    ERROR4 $

219  PRTPARM  //C,N,-4/C,N,DIRFRRD $

220  LABEL    FINIS $

221  END      $
```

3.9.2 Description of DMAP Operations for Direct Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

7. Go to DMAP No. 113 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix is to be assembled.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.

51. EMA assembles structural damping matrix $[K^4_{gg}]$.

57. Go to DMAP No. 61 if no weight and balance is requested.

58. Go to DMAP No. 218 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

62. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 7' if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no grid point singularities exist.

78. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] , \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G_m^T][B_{mn}] + [B_{mn}^T][G_m] + [G_m^T][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G_m^T][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G_m^T][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] , \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] ,$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right] .$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

97. Equivalence $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

99. Go to DMAP No. 113 if no omitted coordinates.

100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o].$$

102. Go to DMAP No. 105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G^T_o][M_{oo}][G_o]$$

106. Go to DMAP No. 109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G^T_o][B_{oo}][G_o]$$

110. Go to DMAP No. 113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Power Spectral Density List and Frequency Response List.

116. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

120. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

124. Go to DMAP No. 127 if no fluid structure interface is defined.

125. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the fluid.

130. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

131. Beginning of loop for additional sets of direct input matrices.

133. CASE extracts user requests from CASECC for current loop.

136. MTRXIN selects the direct input matrices for the current loop, $[K^{2d}_{pp}]$, $[M^{2d}_{pp}]$ and $[B^2_{pp}]$.

140. Equivalence $[M^{2d}_{pp}]$ to $[M^2_{pp}]$ if no $[A_{b,f\ell}]$.

141. ADD5 adds $[K_{b,f\ell}]$ and $[K^{2d}_{pp}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K^2_{pp}]$.

142. Go to DMAP No. 145 if no $[A_{b,f\ell}]$.

143. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

144. ADD assembles input matrix $[M^2_{pp}] = \text{MFACT}\,[A_{b,f\ell}]^T + [M^{2d}_{pp}]$.

150. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points and $[B_{aa}]$ to $[B_{dd}]$ if no direct input damping matrices and no extra points.

152. Go to DMAP No. 154 if only extra points defined.

153. GKAD assembles stiffness, mass, and damping matrices for use in Direct Frequency Response

$$[K_{dd}] = (1 + ig)[K^1_{dd}] + [K^2_{dd}] + i[K^4_{dd}],$$

$$[M_{dd}] = [M^1_{dd}] + [M^2_{dd}] \text{ and}$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] .$$

Direct input matrices may be complex.

155. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ if all stiffness is Direct Matrix Input, $[M^2_{dd}]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[B^2_{dd}]$ to $[B_{dd}]$ if all damping is Direct Matrix Input.

157. Go to DMAP No. 216 and print error message if no Frequency Response List.

158. Go to DMAP No. 214 and print error message if no Dynamics Load Table.

159. FRRD forms the dynamic load vectors $\{P_d\}$ and solves for the displacements using the following equation

$$[-M_{dd}\omega^2 + iB_{dd}\omega + K_{dd}]\{u_d\} = \{P_d\} .$$

160. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

162. VDR prepares displacements, sorted by frequency, for output using only the independent degrees of freedom.

164. Go to DMAP No. 178 if no output request for the independent degrees of freedom.

165. Go to DMAP No. 175 if no output request for independent displacements sorted by point number.

167. SDR3 sorts the independent displacements by point number.

168. ØFP formats the requested independent displacements, sorted by point number, prepared by SDR3 and places them on the system output file for printing.

171. XYTRAN prepares the input for X-Y plotting of the independent displacements vs. frequency.

173. XYPLØT prepares the requested X-Y plots of the independent displacements vs. frequency.

176. ØFP formats the requested independent displacements, sorted by frequency, prepared by VDR and places them on the system output file for printing.

179. Go to DMAP No. 207 if no output request involving dependent degrees of freedom or forces and stresses.

180. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

181. Go to DMAP No. 183 if no constraints applied.

182. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \begin{Bmatrix} u_d \\ \hline u_o \end{Bmatrix} = \{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_f + u_e \\ \hline u_s \end{Bmatrix} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_n + u_e \\ \hline u_m \end{Bmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

185. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares load vectors (ØPPC1), displacement vectors (ØUPVC1), and single-point forces of constraint (ØQPC1) for output sorted by frequency.

187. Go to DMAP No. 204 if no output requests sorted by point number or element number.

188. SDR3 prepares requested output sorted by point number or element number.

190. ØFP formats tables prepared by SDR3, sorted by point number or element number, and places them on the system output file for printing.

192. XYTRAN prepares the input for requested X-Y plots.

194. XYPLØT prepares the requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

195. Go to DMAP No. 207 if no Power Spectral Density List.

196. RANDØM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTØ) using the previously calculated frequency response.

199. Go to DMAP No. 207 if no RANDØM calculations requested.

200. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

202. XYPLØT prepares the requested X-Y plots of autocorrelation functions and power spectral density functions.

203. Go to DMAP No. 207 if no frequency response output requests sorted by frequency.

205. ØFP formats frequency response output requests prepared by SDR2, sorted by frequency, and places them on the system output file for printing.

208. Go to DMAP No. 220 if no additional sets of direct input matrices need to be processed.

209. Go to DMAP No. 131 if additional sets of direct input matrices need to be processed.

210. Go to DMAP No. 212 and print error message if more than 100 loops.

211. Go to DMAP No. 220 and make normal exit.

213. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

215. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

217. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

219. DIRECT FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.9.3 Case Control Deck and Parameters for Direct Frequency and Random Response

The following items relate to subcase definition and data selection for Direct Frequency and Random Response:

1. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.
2. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading conditions - one subcase for each dynamic loading condition.
3. Constraints must be defined above the subcase level.
4. DLØAD must be used to define a frequency-dependent loading condition for each subcase.
5. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck for each unique set of direct input matrices.
6. On restart following an unscheduled exit due to insufficient time, the subcase structure must be changed to reflect the sets of direct input matrices that were completed, and FREQUENCY must be changed to select a FREQ, FREQ1, or FREQ2 card that reflects any frequencies for which the response has already been determined. Otherwise the previous calculations will be repeated.
7. ØFREQUENCY may be used above the subcase level or within each subcase to select a subset of the solution frequencies for output requests. The default is to use all solution frequencies.
8. If Random Response calculations are desired, RANDØM must be used to select RANDPS and RANDT1 cards from the Bulk Data Deck. Only one ØFREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The following printed output, sorted by frequency (SØRT1) or by point number or element number (SØRT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by ØFREQUENCY:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points.

3. Stresses and forces in selected elements (ALL available only for SØRT1).

The following plotter output is available for Frequency Response calculations:

1. Undeformed plot of the structural model.

2. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

3. X-Y plot of any component of the applied load vector or single-point force of constraint.

4. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.3). This is the only form of printed output that is available for Random Response. Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Frequency Response calculations:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - the real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.10 DIRECT TRANSIENT RESPONSE

3.10.1 DMAP Sequence for Direct Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 9

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    NO.9 DIRECT TRANSIENT RESPONSE ANALYSIS - SERIES O $

   2  FILE     KGGX=TAPE/KGG=TAPE/UDVT=APPEND/TOL=APPEND $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET,NOGPDT $

   5  PURGE    USET,GM,GO,KAA,BAA,MAA,K4AA,PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,
               GPSETS,ELSETS/NOGPDT $

   6  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL,USET,GM,GO,KAA,BAA,MAA,K4AA,
               PST,KFS,QP,EST,ECT,PLTSETX,PLTPAR,GPSETS,ELSETS $

   7  COND     LBL5,NOGPDT $

   8  GP2      GEOM2,EQEXIN/ECT $

   9  CHKPNT   ECT $

  10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  12  COND     P1,NOPCDB $

  13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

  14  SAVE     NSIL,JUMPPLOT $

  15  PRTMSG   PLTSETX// $

  16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $


  18  COND     P1,JUMPPLOT $

  19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  20  SAVE     JUMPPLOT,PLTFLG,PFILE $

  21  PRTMSG   PLOTX1// $

  22  LABEL    P1 $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  CHKPNT   PLTPAR,GPSETS,ELSETS $

24  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

25  CHKPNT   SLT,GPTT $

26  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP=-1/C,N,1/V,N,NOGENL=-1/V,N,GENEL $

27  SAVE     NOSIMP,NOGENL,GENEL $

28  PURGE    K4GG,GPST,OGPST,MGG,BGG,  K4NN,K4FF,K4AA,MNN,MFF,MAA,BNN,BFF,
             BAA,KGGX/NOSIMP/ OGPST/GENEL $

29  CHKPNT   EST,GPECT,GEI,K4GG,GPST,MGG,BGG,KGGX,OGPST,  K4NN,K4FF,K4AA,
             MNN,MFF,MAA,BNN,BFF,BAA $

30  COND     LBL1,NOSIMP $

31  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

32  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

33  PARAM    //C,N,ADD/V,N,NOBGG=-1/C,N,1/C,N,0 $

34  PARAM    //C,N,ADD/V,N,NOK4GG/C,N,1/C,N,0 $

35  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,BELM,BDICT/   V,
             N,NOKGGX/V,N,NOMGG/V,N,NOBGG/V,N,NOK4GG/C,N,/C,Y,COUPMASS/C,Y,
             CPBAR/C,Y,CPROD/C,Y,CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,
             CPTRIA2/C,Y,CPTUBE/C,Y,CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

36  SAVE     NOKGGX,NOMGG,NOBGG,NOK4GG $

37  CHKPNT   KELM,KDICT,MELM,MDICT,BELM,BDICT $

38  COND     LBLKGGX,NOKGGX $

39  EMA      GPECT,KDICT,KELM/KGGX,GPST $

40  CHKPNT   KGGX,GPST $

41  LABEL    LBLKGGX $

42  COND     LBLMGG,NOMGG $

43  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

44  CHKPNT   MGG $

45  LABEL    LBLMGG $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
46  COND      LBLBGG,NOBGG $
47  EMA       GPECT,BDICT,BELM/BGG, $
48  CHKPNT    BGG $
49  LABEL     LBLBGG $
50  COND      LBLK4GG,NOK4GG $
51  EMA       GPECT,KDICT,KELM/K4GG,/V,N,NOK4GG $
52  CHKPNT    K4GG $
53  LABEL     LBLK4GG $
54  PURGE     MNN,MFF,MAA/NOMGG $
55  PURGE     BNN,BFF,BAA/NOBGG $
56  CHKPNT    MGG,MNN,MFF,MAA,BGG,BNN,BFF,BAA $
57  COND      LBL1,GPDPNT $
58  COND      ERROR3,NOMGG $
59  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
60  OFP       OGPWG,,,,,// $
61  LABEL     LBL1 $
62  EQUIV     KGGX,KGG/NOGENL $
63  CHKPNT    KGG $
64  COND      LBL11,NOGENL $
65  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

66  CHKPNT    KGG $
67  LABEL     LBL11 $
68  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
69  GP4       CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
70  SAVE      MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NSKIP,REPEAT,NOL,NOA $
```

RIGID FORMAT DMAP LISTING
SERIES C

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
71  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST,QP/SINGLE $
72  CHKPNT   GM,GMD,RG,GO,GOD,KFS,PST,QP,USET $
73  COND     LBL4,GENEL $
74  COND     LBL4,NOSIMP $
75  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
76  SAVE     NOGPST $
77  COND     LBL4,NOGPST $
78  OFP      OGPST,,,,,// $
79  LABEL    LBL4 $
80  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1/ BGG,BNN/MPCF1/K4GG,K4NN/MPCF1 $
81  CHKPNT   KNN,MNN,BNN,K4NN $
82  COND     LBL2,MPCF1 $
83  MCE1     USET,RG/GM $
84  CHKPNT   GM $
85  MCE2     USET,GM,KGG,MGG,BGG,K4GG/KNN,MNN,BNN,K4NN $
86  CHKPNT   KNN,MNN,BNN,K4NN $
87  LABEL    LBL2 $
88  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE/BNN,BFF/SINGLE/K4NN,K4FF/SINGLE $
89  CHKPNT   KFF,MFF,BFF,K4FF $
90  COND     LBL3,SINGLE $

91  SCE1     USET,KNN,MNN,BNN,K4NN/KFF,KFS, ,MFF,BFF,K4FF $
92  CHKPNT   KFS,KFF,MFF,BFF,K4FF $
93  LABEL    LBL3 $
94  EQUIV    KFF,KAA/OMIT $
95  EQUIV    MFF,MAA/OMIT $
96  EQUIV    BFF,BAA/OMIT $
```


c - 6

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 97  EQUIV    K4FF,K4AA/OMIT $

 98  CHKPNT   KAA,MAA,BAA,K4AA $

 99  COND     LBL5,OMIT $

100  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

101  CHKPNT   GO,KAA $

102  COND     LBLM,NOMGG $

103  SMP2     USET,GO,MFF/MAA $

104  CHKPNT   MAA $

105  LABEL    LBLM $

106  COND     LBLB,NOBGG $

107  SMP2     USET,GO,BFF/BAA $

108  CHKPNT   BAA $

109  LABEL    LBLB $

110  COND     LBL5,NOK4GG $

111  SMP2     USET,GO,K4FF/K4AA $

112  CHKPNT   K4AA $

113  LABEL    LBL5 $

114  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,,
              EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/  V,
              N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

115  SAVE     LUSETD,NODLT,NONLFT,NOTRL,NOUE $


116  PURGE    PNLD/NONLFT$

117  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

118  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,GOD,GMD,NLFT,PNLD,SILD,GPLD $

119  BMG      MATPOOL,BGPDT,EQEXIN,CSTM/BDPOOL/V,N,NOKBFL/V,N,NOABFL/ V,N,
              MFACT $

120  SAVE     MFACT,NOKBFL,NOABFL $

121  PARAM    //C,N,AND/V,N,NOBFL/V,N,NOABFL/V,N,NOKBFL $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  PURGE    KBFL/NOKBFL/ ABFL/NOABFL $

123  COND     LBLFL3,NOFL $

124  MTRXIN   ,BDPOOL,EQDYN,,/ABFL,KBFL,/V,N,LUSETD/V,N,NOABFL/V,N,NOKBFL/C,
              N,0 $

125  SAVE     NOABFL,NOKBFL $

126  LABEL    LBLFL3 $

127  CHKPNT   ABFL,KBFL $

128  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2DPP,M2DPP,B2PP/V,N,LUSETD/V,N,
              NOK2DPP/V,N,NOM2DPP/V,N,NOB2PP $

129  SAVE     NOK2DPP,NOM2DPP,NOB2PP $

130  PARAM    //C,N,AND/V,N,NOM2PP/V,N,NOABFL/V,N,NOM2DPP $

131  PARAM    //C,N,AND/V,N,NOK2PP/V,N,NOFL /V,N,NOK2DPP $

132  EQUIV    M2DPP,M2PP/NOABFL $

133  ADD5     ABFL,KBFL,K2DPP,,/K2PP/C,N,(-1.0,0.0) $

134  COND     LBLFL2,NOABFL $

135  TRNSP    ABFL/ABFLT $

136  ADD      ABFLT,M2DPP/M2PP/V,N,MFACT $

137  LABEL    LBLFL2 $

138  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

139  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

140  PARAM    //C,N,AND/V,N,KDEK2/V,N,NOGENL/V,N,NOSIMP $


141  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

142  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA/  KAA,
              KDD/KDEKA $

143  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD,KDD $

144  COND     LBL16,NOGPDT $

145  GKAD     USETD,GM,GO,KAA,BAA,MAA,K4AA,K2PP,M2PP,B2PP/KDD,BDD,MDD,GMD,
              GOD,K2DD,M2DD,B2DD/C,N,TRANRESP/C,N,DISP/C,N,DIRECT/C,Y,G=0.0/
              C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/ V,N,
```

DIRECT TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/V,N,NOK4GG/V,N,NOBGG/V,N,
                KDEK2/C,N,-1 $

146  LABEL      LBL16 $

147  EQUIV      M2DD,MDD/NOSIMP/B2DD,BDD/NOGPDT/K2DD,KDD/KDEK2 $

148  CHKPNT     KDD,BDD,MDD,GMD,GOD $

149  COND       ERROR1,NOTRL $

150  PARAM      //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

151  PARAM      //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

152  PARAM      //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

153  JUMP       LBL13 $
------------------------------------------------------ Top of DMAP Loop
154  LABEL      LBL13 $

155  PURGE      PNLD,OUDV1,OPNL1,OUDV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
                OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT/NEVER $

156  CASE       CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $

157  SAVE       REPEATT,NOLOOP $

158  CHKPNT     CASEXX $

159  PARAM      //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $

160  TRLG       CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,,EST,MGG/
                PPT,PST,PDT,PD,,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL $

161  SAVE       PDEPDO,NOSET $

162  CHKPNT     PPT,PST,PDT,PD,TOL $

163  EQUIV      PD,PDT/PDEPDO/PPT,PDT/NOSET $


164  CHKPNT     PDT $

165  TRD        CASEXX,TRL,NLFT,DIT,KDD,BDD,MDD,PD/UDVT,PNLD/C,N,DIRECT/V,N,
                NOUE/V,N,NONCUP/V,N,NCOL/C,Y,ISTART $

166  SAVE       NCOL $

167  CHKPNT     UDVT,PNLD $

168  VDR        CASEXX,EQDYN,USETD,UDVT,TOL,XYCDB,PNLD/OUDV1,OPNL1/ C,N,
                TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
169  SAVE      NOD,NOF $
170  CHKPNT    OUDV1,OPNL1 $
171  COND      LBL15,NOD $
172  SDR3      OUDV1,OPNL1,,,,/OUDV2,OPNL2,,,, $
173  OFP       OUDV2,OPNL2,,,,//V,N,CARDNO $
174  SAVE      CARDNO $
175  CHKPNT    OPNL2,OUDV2 $
176  XYTRAN    XYCDB,OUDV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,DSET/V,N,PFILE/V,N,
               CARDNO $
177  SAVE      PFILE,CARDNO $
178  XYPLOT    XYPLTTA// $
179  LABEL     LBL15 $
180  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
181  COND      LBL18,PJUMP $
182  EQUIV     UDVT,UPV/NOA $
183  COND      LBL17,NOA $
184  SDR1      USETD,,UDVT,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $
185  LABEL     LBL17 $
186  CHKPNT    UPV,QP $
187  SDR2      CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
               PPT/OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $

188  SDR3      OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $
189  CHKPNT    OPP2,OQP2,OUPV2,OES2,OEF2 $
190  OFP       OPP2,OQP2,OUPV2,OEF2,OES2,//V,N,CARDNO $
191  SAVE      CARDNO $
192  COND      P2,JUMPPLOT $
193  PLOT      PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

DIRECT TRANSIENT RESPONSE

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
194  SAVE     PFILE $

195  PRTMSG   PLOTX2// $

196  LABEL    P2 $

197  XYTRAN   XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
              PFILE/V,N,CARDNO $

198  SAVE     PFILE,CARDNO $

199  XYPLOT   XYPLTT// $

200  LABEL    LBL18 $

201  COND     FINIS,REPEATT $

202  REPT     LBL13,100 $
------------------------------------------------------ Bottom of DMAP Loop
203  JUMP     ERROR2 $

204  JUMP     FINIS $

205  LABEL    ERROR2 $

206  PRTPARM  //C,N,-2/C,N,DIRTRD $

207  LABEL    ERROR1 $

208  PRTPARM  //C,N,-1/C,N,DIRTRD $

209  LABEL    ERROR3 $

210  PRTPARM  //C,N,-3/C,N,DIRTRD $

211  LABEL    FINIS $

212  END      $
```

3.10.2 Description of DMAP Operations for Direct Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid poin^ locations, and tables to relate internal to external grid point numbers.

7. Go to DMAP No. 113 if only Direct Matrix Input.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly and stress recovery.

30. Go to DMAP No. 61 if there are no structural elements.

35. EMG generates structural element stiffness, mass, and damping matrix tables and dictionaries for later assembly.

38. Go to DMAP No. 41 if no stiffness matrix is to be assembled.

39. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

42. Go to DMAP No. 45 if no mass matrix is to be assembled.

43. EMA assembles mass matrix $[M_{gg}]$.

46. Go to DMAP No. 49 if no viscous damping matrix is to be assembled.

47. EMA assembles viscous damping matrix $[B_{gg}]$.

50. Go to DMAP No. 53 if no structural damping matrix is to be assembled.

51. EMA assembles structural damping matrix $[K_{gg}^{4}]$.

57. Go to DMAP No. 61 if no weight and balance is requested.

58. Go to DMAP No. 209 and print error message if no mass matrix exists.

59. GPWG generates weight and balance information.

60. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

62. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

64. Go to DMAP No. 67 if no general elements.

65. SMA3 adds general elements to $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

69. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

73. Go to DMAP No. 79 if general elements present.

74. Go to DMAP No. 79 if no structural elements.

75. GPSP determines if possible grid point singularities remain.

77. Go to DMAP No. 79 if no grid point singularities exist.

78. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

80. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[M_{gg}]$ to $[M_{nn}]$, $[B_{gg}]$ to $[B_{nn}]$ and $[K^4_{gg}]$ to $[K^4_{nn}]$ if no multipoint constraints.

82. Go to DMAP No. 87 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

83. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

85. MCE2 partitions stiffness, mass and damping matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right], \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right],$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] \quad \text{and} \quad [K^4_{gg}] = \left[\begin{array}{c|c} \bar{K}^4_{nn} & K^4_{nm} \\ \hline K^4_{mn} & K^4_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G^T_m][K_{mn}] + [K^T_{mn}][G_m] + [G^T_m][K_{mm}][G_m],$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G^T_m][M_{mn}] + [M^T_{mn}][G_m] + [G^T_m][M_{mm}][G_m],$$

$$[B_{nn}] = [\bar{B}_{nn}] + [G^T_m][B_{mn}] + [B^T_{mn}][G_m] + [G^T_m][B_{mm}][G_m],$$

$$[K^4_{nn}] = [\bar{K}^4_{nn}] + [G^T_m][K^4_{mn}] + [K^4_{mn}]^T[G_m] + [G^T_m][K^4_{mm}][G_m].$$

88. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[M_{nn}]$ to $[M_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$ and $[K^4_{nn}]$ to $[K^4_{ff}]$ if no single-point constraints.

90. Go to DMAP No. 93 if no single-point constraints.

91. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right], \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right],$$

$$[B_{nn}] = \left[\begin{array}{c|c} B_{ff} & B_{fs} \\ \hline B_{sf} & B_{ss} \end{array}\right] \quad \text{and} \quad [K^4_{nn}] = \left[\begin{array}{c|c} K^4_{ff} & K^4_{fs} \\ \hline K^4_{sf} & K^4_{ss} \end{array}\right].$$

94. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

95. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

96. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

97. Equivalence $[K^4_{ff}]$ to $[K^4_{aa}]$ if no omitted coordinates.

99. Go to DMAP No. 113 if no omitted coordinates.

100. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} K_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = [K_{oo}]^{-1}[K_{oa}]$
and performs matrix reduction

$$[K^1_{aa}] = [K_{aa}] + [K_{ao}][G_o]$$

102. Go to DMAP No.105 if no mass matrix.

103. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} M_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M^1_{aa}] = [M_{aa}] + [M_{ao}][G_o] + [M_{ao}G_o]^T + [G_o^T][M_{oo}][G_o]$$

106. Go to DMAP No.109 if no viscous damping matrix.

107. SMP2 partitions constrained viscous damping matrix

$$[B_{ff}] = \left[\begin{array}{c|c} B_{aa} & B_{ao} \\ \hline B_{oa} & B_{oo} \end{array}\right]$$

and performs matrix reduction

$$[B^1_{aa}] = [B_{aa}] + [B_{ao}][G_o] + [B_{ao}G_o]^T + [G_o^T][B_{oo}][G_o]$$

110. Go to DMAP No.113 if no structural damping matrix.

111. SMP2 partitions constrained structural damping matrix

$$[K^4_{ff}] = \left[\begin{array}{c|c} K^4_{aa} & K^4_{ao} \\ \hline K^4_{oa} & K^4_{oo} \end{array}\right]$$

and performs matrix reduction

$$[K^4_{aa}] = [K^4_{aa}] + [K^4_{ao}][G_o] + [K^4_{ao}G_o]^T + [G_o^T][K^4_{oo}][G_o]$$

114. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamics Load Table, Nonlinear Function Table and Transient Response List.

117. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

119. BMG generates DMIG card images describing the interconnection of the fluid and the structure.

123. Go to DMAP No. 126 if no fluid structure interface is defined.

124. MTRXIN generates fluid boundary matrices $[A_{b,f\ell}]$ and $[K_{b,f\ell}]$ if a fluid structure interface is defined. The matrix $[K_{b,f\ell}]$ is generated only for a nonzero gravity in the field.

128. MTRXIN selects the direct input matrices $[K_{pp}^{2d}]$, $[M_{pp}^{2d}]$ and $[B_{pp}^2]$.

132. Equivalence $[M_{pp}^{2d}]$ to $[M_{pp}^2]$ if no $[A_{b,f\ell}]$.

133. ADD5 adds $[K_{b,f\ell}]$ and $[K_{pp}^{2d}]$ and subtracts $[A_{b,f\ell}]$ from them to form $[K_{pp}^2]$.

134. Go to DMAP No. 137 if no $[A_{b,f\ell}]$.

135. Transpose $[A_{b,f\ell}]$ to obtain $[A_{b,f\ell}]^T$.

136. ADD assembles input matrix $[M_{pp}^2]$ = MFACT $[A_{b,f\ell}]^T + [M_{pp}^{2d}]$.

142. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied, $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points, and $[K_{aa}]$ to $[K_{dd}]$ if no direct input stiffness matrices and no extra points.

144. Go to DMAP No. 146 if only extra points defined.

145. GKAD assembles stiffness, mass, and damping matrices for use in Direct Transient Response

$$[K_{dd}] = [K_{dd}^1] + [K_{dd}^2],$$

$$[M_{dd}] = [M_{dd}^1] + [M_{dd}^2],$$

and

$$[B_{dd}] = [B_{dd}^1] + [B_{dd}^2] + \frac{g}{\omega_3}[K_{dd}^1] + \frac{1}{\omega_4}[K_{dd}^4],$$

where

$$\left[\begin{array}{c|c} K_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] \Rightarrow [K_{dd}^1],$$

$$\left[\begin{array}{c|c} M_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] \Rightarrow [M_{dd}^1],$$

$$\left[\begin{array}{c|c} B_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] \Rightarrow [B_{dd}^1].$$

and $\left[\begin{array}{c|c} K_{aa}^4 & 0 \\ \hline 0 & 0 \end{array}\right] \rightarrow [K_{dd}^4]$.

All matrices are real.

147. Equivalence $[B_{dd}^2]$ to $[B_{dd}]$ if all damping is Direct Matrix Input, $[M_{dd}^2]$ to $[M_{dd}]$ if all mass is Direct Matrix Input and $[K_{dd}^2]$ to $[K_{dd}]$ is all stiffness is Direct Matrix Input.

149. Go to DMAP No. 207 and print error message if no Transient Response List.

153. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

154. Beginning of loop for additional dynamic load sets.

156. CASE extracts user requests from CASECC for current loop.

160. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ is generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

163. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_p^t\}$ to $\{P_d^t\}$ if the d and p sets are the same.

165. TRD forms the linear, $\{P_d\}$, and nonlinear, $\{P_d^{n\ell}\}$, dynamic load vectors and integrates the equations of motion (using the standard starting procedure) over specified time periods to solve for the displacements, velocities, and accelerations, using the following equation

$$[M_{dd}p^2 + B_{dd}p + K_{dd}]\{u_d\} = \{P_d\} + \{P_d^{n\ell}\} \ .$$

168. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the independent degrees of freedom.

171. Go to DMAP No. 179 if no output request for the independent degrees of freedom.

172. SDR3 prepares requested output of the independent displacements, velocities, accelerations and nonlinear load vectors sorted by point number or element number.

173. ØFP formats tables prepared by SDR3 sorted by point number or element number and places them on the system output file for printing.

176. XYTRAN prepares the input for X-Y plotting of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

178. XYPLØT prepares requested X-Y plots of the independent displacements, velocities, accelerations and nonlinear load vectors vs. time.

181. Go to DMAP No. 200 if no output request involving dependent degrees of freedom or forces and stresses.

182. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

183. Go to DMAP No. 185 if no constraints applied.

184. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \left\{\begin{array}{c} u_d \\ \hline u_o \end{array}\right\} = \{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_f + u_e \\ \hline u_s \end{array}\right\} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\left\{\begin{array}{c} u_n + u_e \\ \hline u_m \end{array}\right\} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

187. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPP1), displacement, velocity and acceleration vectors (ØUPV1) and single-point forces of constraint (ØQP1) for output and translation components of the displacement vector (PUGV) sorted by time step.

188. SDR3 prepares requested output sorted by point number of element number.

190. ØFP formats tables prepared by SDR3 for output sorted by point number of element number and places them on the system output file for printing.

192. Go to DMAP No. 196 if no deformed structure plots requested.

193. PLØT prepares all requested deformed structure and contour plots.

195. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

197. XYTRAN prepares the input for requested X-Y plots.

199. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint versus time.

201. Go to DMAP No. 211 if no additional dynamic load sets need to be processed.

202. Go to DMAP No. 154 if additional dynamic load sets need to be processed.

203. Go to DMAP No. 205 and print error message if more than 100 loops.

204. Go to DMAP No. 211 and make normal exit.

206. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

208. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

210. DIRECT TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

3.10.3 Case Control Deck and Parameters for Direct Transient Response

The following items relate to subcase definition and data selection for Direct Transient Response:

1. One subcase must be defined for each dynamic loading condition.

2. DLØAD or NØNLINEAR must be used to define a time-dependent loading condition for each subcase.

3. Constraints must be defined above the subcase level.

4. TSTEP must be used to select the time-step intervals to be used for integration and output in each subcase.

5. If nonzero initial conditions are desired, IC must be used to select a TIC card in the Bulk Data Deck.

6. On restart following an unscheduled exit due to insufficient time, the subcase structure should be changed to reflect any completed loading conditions. The TSTEP selections must be changed if it is desired to resume the integration at the point terminated.

The following printed output, sorted by point number or element number (SØRT2) is available at selected multiples of the integration time step:

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system).

2. Nonzero components of the applied load vector and single point forces of constraint for a list of PHYSICAL points.

3. Nonlinear force vector for a list of SØLUTIØN points.

4. Stresses and forces in selected elements (All not allowed).

The following plotter output is available for Transient Response:

1. Undeformed plot of the structural model.

2. Deformed shapes of the structural model for selected time intervals.

3. Contour plots of stress and displacement for selected time intervals.

4. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

5. X-Y plot of any component of the applied load vector, nonlinear force vector, or single-point force of constraint.

6. X-Y plot of any stress or force component for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Direct Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. G - optional - The real value of this parameter is used as a uniform structural damping coefficient in the direct formulation of dynamics problems. Not recommended for use in hydroelastic problems.

4. W3 and W4 - optional - The values of these parameters are used as pivotal frequencies for uniform structural damping and element structural damping respectively. W3 is required if uniform structural damping is desired. W4 is required if structural damping is desired for any of the structural elements. See page 9.3-8 of the NASTRAN Theoretical Manual.

5. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

6. ISTART - optional - A positive value of this parameter will cause the TRD module to use the second (or alternate) starting method (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular.

3.11 MODAL COMPLEX EIGENVALUE ANALYSIS

3.11.1 DMAP Sequence for Modal Complex Eigenvalue Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

  1  BEGIN    NO.10 MODAL COMPLEX EIGENVALUE ANALYSIS - SERIES 0 $

  2  FILE     GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

  3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
              NOGPDT $

  4  SAVE     LUSET $

  5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2      GEOM2,EQEXIN/ECT $

  7  CHKPNT   ECT $

  8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND     P1,NOPCDB $

 11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
              JUMPPLOT=-1 $

 12  SAVE     NSIL,JUMPPLOT $

 13  PRTMSG   PLTSETX// $

 14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND     P1,JUMPPLOT $

 17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
              NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE     PFILE $


 19  PRTMSG   PLOTX1// $

 20  LABEL    P1 $

 21  CHKPNT   PLTPAR,GPSETS,ELSETS $

 22  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

 23  CHKPNT   GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $
25  SAVE     NOGENL,NOSIMP,GENEL $
26  COND     ERROR1,NOSIMP $
27  PURGE    OGPST/GENEL $
28  CHKPNT   EST,GPECT,GEI,OGPST $
29  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $
30  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $
31  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $
32  SAVE     NOKGGX,NOMGG $
33  CHKPNT   KELM,KDICT,MELM,MDICT $
34  COND     JMPKGGX,NOKGGX $
35  EMA      GPECT,KDICT,KELM/KGGX,GPST $
36  CHKPNT   KGGX,GPST $
37  LABEL    JMPKGGX $
38  COND     ERROR1,NOMGG $
39  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
40  CHKPNT   MGG $
41  COND     LGPWG,GRDPNT $

42  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $
43  OFP      OGPWG,,,,,// $
44  LABEL    LGPWG $
45  EQUIV    KGGX,KGG/NOGENL $
46  CHKPNT   KGG $
47  COND     LBL11,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT   KGG $
50  LABEL    LBL11 $
51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,O/C,N,O $
52  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM    //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
55  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS/SINGLE/QPC/NOSR/KLR,KRR,MLR,MRR,
             DM,MR/REACT $
56  CHKPNT   KRR,KLR,DM,MLR,MPR,MR,GM,RG,GO,KFS,QPC,USET,GMD,GOD,ASET $
57  COND     LBL4,GENEL $
58  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE     NOGPST $
60  COND     LBL4,NOGPST $
61  OFP      OGPST,,,,,// $
62  LABEL    LBL4 $
63  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT   KNN,MNN $
65  COND     LBL2,MPCF1 $
66  MCE1     USET,RG/GM $

67  CHKPNT   GM $
68  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT   KNN,MNN $
70  LABEL    LBL2 $
71  EQUIV    KNN,KFF/SINGLE/KNN,MFF/SINGLE $
72  CHKPNT   KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND      LBL3,SINGLE $

74  SCE1      USET,KNN,MNN,,/KFF,KFS,,MFF,, $

75  CHKPNT    KFS,KFF,MFF $

76  LABEL     LBL3 $

77  EQUIV     KFF,KAA/OMIT $

78  EQUIV     MFF,MAA/OMIT $

79  CHKPNT    KAA,MAA $

80  COND      LBL5,OMIT $

81  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

82  CHKPNT    GO,KAA $

83  SMP2      USET,GO,MFF/MAA $

84  CHKPNT    MAA $

85  LABEL     LBL5 $

86  COND      LBL6,REACT $

87  RBMG1     USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

88  CHKPNT    KLL,KLR,KRR,MLL,MLR,MRR $

89  RBMG2     KLL/LLL $

90  CHKPNT    LLL $

91  RBMG3     LLL,KLR,KRR/DM $

92  CHKPNT    DM $


93  RBMG4     DM,MLL,MLR,MRR/MR $

94  CHKPNT    MR $

95  LABEL     LBL6 $

96  DPD       DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
              N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

97  SAVE      LUSETD,NOUE,NOEED $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  COND     ERROR2,NOEED $

 99  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

100  CHKPNT   USETD,EED,EQDYN,TFPOOL,GOD,GMD,SILD,GPLD $

101  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

102  READ     KAA,MAA,MP,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

103  SAVE     NEIGV $

104  CHKPNT   LAMA,PHIA,MI,OEIGS $

105  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

106  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

107  SAVE     CARDNO $

108  COND     ERROR4,NEIGV $

109  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

110  PARAM    //C,N,MPY/V,N,REPEATE/C,N,1/C,N,-1 $

111  JUMP     LBL13 $
-------------------------------------------------- Top of DMAP Loop
112  LABEL    LBL13 $

113  PURGE    PHIH,CLAMA,CPHIH,CPHID,CPHIP,QPC,OQPC1,OCPHIP,OESC1,OEFC1,K2PP,
              M2PP,B2PP,K2DD,M2DD,B2DD/NEVER $

114  CASE     CASECC,/CASEXX/C,N,CEIGN/V,N,REPEATE/V,N,NOLOOP $

115  SAVE     REPEATE,NOLOOP $

116  CHKPNT   CASEXX $


117  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

118  SAVE     NOK2PP,NOM2PP,NOB2PP $

119  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

120  EQUIV    M2PP,M2DD/NOSET/B2PP,B2DD/NOSET/K2PP,K2DD/NOSET $

121  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

122  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/
              C,N,-1/C,N,-1/   C,N,-1/C,N,-1 $

123  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

124  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,  NOM2PP/
              V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

125  SAVE     NONCUP,FMODE $

126  CHKPNT   MHH,BHH,KHH,PHIDH $

127  CEAD     KHH,BHH,MHH,EED,CASEXX/PHIH,CLAMA,OCEIGS/V,N,EIGVS $

128  SAVE     EIGVS $

129  CHKPNT   PHIH,CLAMA,OCEIGS $

130  OFP      OCEIGS,CLAMA,,,,//V,N,CARDNO $

131  SAVE     CARDNO $

132  COND     LBL17,EIGVS $

133  VDR      CASEXX,EQDYN,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/V,
              N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

134  SAVE     NOH,NOP $

135  COND     LBL16,NOH $

136  OFP      OPHIH,,,,,//V,N,CARDNO $

137  SAVE     CARDNO $

138  LABEL    LBL16 $

139  COND     LBL17,NOP $


140  DDR1     PHIH,PHIDH/CPHID $

141  CHKPNT   CPHID $

142  EQUIV    CPHID,CPHIP/NOA $

143  COND     LBLNOA,NOA $

144  SDR1     USETD,,CPHID,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS $

145  LABEL    LBLNOA $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
146  CHKPNT   CPHIP,QPC $
147  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,CLAMA,QPC,CPHIP,EST,,/      ,
              OQPC1,OCPHIP,OESC1,OEFC1, /C,N,CEIGEN $
148  OFP      OCPHIP,OQPC1,OEFC1,OESC1,,//V,N,CARDNO $
149  SAVE     CARDNO $
150  LABEL    LBL17 $
151  COND     FINIS,REPEATE $
152  REPT     LBL13,100 $
------------------------------------------------------------ Bottom of DMAP Loop
153  JUMP     ERROR3 $
154  JUMP     FINIS $
155  LABEL    ERROR3 $
156  PRTPARM  //C,N,-3/C,N,MDLCEAD $
157  LABEL    ERROR2 $
158  PRTPARM  //C,N,-2/C,N,MDLCEAD $
159  LABEL    ERROR1 $
160  PRTPARM  //C,N,-1/C,N,MDLCEAD $
161  LABEL    ERROR4 $
162  PRTPARM  //C,N,-4/C,N,MDLCEAD $
163  LABEL    FINIS $
164  END      $
```

3.11.2 Description of DMAP Operations for Modal Complex Eigenvalue Analysis

3. GP1 generates coordinate system transformation matrices, table of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 159 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 159 if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no Grid Point Singularity Table.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \quad \text{and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o]$$

86. Go to DMAP No. 95 if no free-body supports.

87. RBMG1 partitions out free-body supports.

89. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

91. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K^T_{\ell r}][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

93. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M^T_{\ell r}][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

96. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

98. Go to DMAP No. 157 and print error message if no Eigenvalue Extraction Data.

99. Equivalence $[G_o]$ to $[G^d_o]$ and $[G_m]$ to $[G^d_m]$ if no extra points introduced for dynamic analysis.

102. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi^T_{ro}][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D_m \ \phi_{ro} \\ --- \\ \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi^T_a][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:
1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

106. ØFP formats the summary of eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

108. Go to DMAP No. 161 and print error message if no eigenvalues found.

111. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

112. Beginning of loop for additional sets of direct input matrices.

114. CASE extracts user requests from CASECC for current loop.

117. MTRXIN selects the direct input matrices for the current loop, $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

120. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

122. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

124. GKAM assembles stiffness, mass and damping matrices in modal coordinates for use in Complex Eigenvalue Analysis.

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}],$$

where m_i = modal masses

$b_i = m_i \, 2\pi \, f_i \, g(f_i)$

$k_i = m_i \, 4\pi^2 \, f_i^2$

and direct input matrices may be complex.

127. CEAD extracts complex eigenvalues from the equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = 0$$

and normalizes eigenvectors according to one of the following user requests:
(1) Unit magnitude of selected coordinate
(2) Unit magnitude of largest component.

130. ØFP formats the summary of complex eigenvalues (CLAMA) and summary of eigenvalue extraction information (ØCEIGS) prepared by CEAD and places them on the system output file for printing.

132. Go to DMAP No. 150 if no complex eigenvalues found.

133. VDR prepares eigenvectors (ØPHIH) for output, using only the extra points introduced for dynamic analysis and modal coordinates.

135. Go to DMAP No. 138 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

136. ØFP formats tables of eigenvectors for extra points introduced for dynamic analysis and modal coordinates prepared by VDR and places them on the system output file for printing.

138. Go to DMAP No. 150 if no output request involving dependent degrees of freedom or forces and stresses.

140. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$[\phi_d] = [\phi_{dh}][\phi_h].$$

142. Equivalence $[\phi_d]$ to $[\phi_p]$ if no constraints applied.

143. Go to DMAP No. 145 if no constraints applied.

144. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_d\} \quad , \qquad \begin{Bmatrix} \phi_d \\ -- \\ \phi_o \end{Bmatrix} = \{\phi_f + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_f + \phi_e \\ --- \\ \phi_s \end{Bmatrix} = \{\phi_n + \phi_e\} \quad , \qquad \{\phi_m\} = [G_m^d]\{\phi_n + \phi_e\} \quad ,$$

$$\begin{Bmatrix} \phi_n + \phi_e \\ --- \\ \phi_m \end{Bmatrix} = \{\phi_p\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

147. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares eigenvectors (ØCPHIP) and single-point forces of constraint (ØQPC1) for output.

148. ØFP formats tables prepared by SDR2 and places them on system output file for printing.

151. Go to DMAP No. 163 if no additional sets of direct input matrices need to be processed.

152. Go to DMAP No.112 if additional sets of direct input matrices need to be processed.

153. Go to DMAP No.155 and print error message if more than 100 loops.

154. Go to DMAP No.163 and make normal exit.

156. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

158. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

160. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

162. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.11.3 Automatic Output for Modal Complex Eigenvalue Analysis

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

The Complex Eigenvalue Summary Table and the Complex Eigenvalue Analysis Summary, as described under Direct Complex Eigenvalue Analysis, are automatically printed for each set of direct input matrices.

3.11.4 Case Control Deck and Parameters for Modal Complex Eigenvalue Analysis

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Complex Eigenvalue Analysis:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Complex Eigenvalue Analysis. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Complex Eigenvalue Analysis:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

3.11.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.12 MODAL FREQUENCY AND RANDOM RESPONSE

3.12.1 DMAP Sequence for Modal Frequency and Random Response

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.11 MODAL FREQUENCY RESPONSE ANALYSIS - SERIES 0 $

    2  FILE     GOD=SAVE/ GMD=SAVE/ LAMA=APPEND/ PHIA=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

   23  CHKPNT   GPTT $
```

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 11

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


24  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE     NOGENL,NOSIMP,GENEL $

26  COND     ERROR1,NOSIMP $

27  PURGE    OGPST/GENEL $

28  CHKPNT   EST,GPECT,GEI,OGPST $

29  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM    //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE     NOKGGX,NOMGG $

33  CHKPNT   KELM,KDICT,MELM,MDICT $

34  COND     JMPKGGX,NOKGGX $

35  EMA      GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT   KGGX,GPST $

37  LABEL    JMPKGGX $

38  COND     ERROR1,NOMGG $

39  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT   MGG $

41  COND     LGPWG,GRDPNT $


42  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP      OGPWG,,,,,// $

44  LABEL    LGPWG $

45  EQUIV    KGGX,KGG/NOGENL $

46  CHKPNT   KGG $

47  COND     LBL11,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
49  CHKPNT   KGG $
50  LABEL    LBL11 $
51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $
52  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $
53  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $
54  PARAM    //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $
55  PURGE    GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PSF/SINGLE/QPC/NOSR/KLR,KRR,MLR,
             MRR,DM,MR/REACT/MDD/MODACC $
56  CHKPNT   KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PSF,QPC,USET,GOD,GMD,ASET $
57  COND     LBL4,GENEL $
58  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $
59  SAVE     NOGPST $
60  COND     LBL4,NOGPST $
61  OFP      OGPST,,,,,// $
62  LABEL    LBL4 $
63  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $
64  CHKPNT   KNN,MNN $
65  COND     LBL2,MPCF1 $
66  MCE1     USET,RG/GM $

67  CHKPNT   GM $
68  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
69  CHKPNT   KNN,MNN $
70  LABEL    LBL2 $
71  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
72  CHKPNT   KFF,MFF $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  COND     LBL3,SINGLE $
74  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $
75  CHKPNT   KFS,KFF,MFF $
76  LABEL    LBL3 $
77  EQUIV    KFF,KAA/OMIT $
78  EQUIV    MFF,MAA/OMIT $
79  CHKPNT   KAA,MAA $
80  COND     LBL5,OMIT $
81  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
82  CHKPNT   GO,KAA $
83  SMP2     USET,GO,MFF/MAA $
84  CHKPNT   MAA $
85  LABEL    LBL5 $
86  EQUIV    KAA,KLL/REACT $
87  CHKPNT   KLL $
88  COND     LBL6,REACT $
89  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $
90  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $
91  JUMP     LBL8 $
92  LABEL    LBL6 $

93  COND     LBL7,MODACC $
94  LABEL    LBL8 $
95  RBMG2    KLL/LLL $
96  CHKPNT   LLL $
97  COND     LBL7,REACT $
98  RBMG3    LLL,KLR,KRR/DM $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  CHKPNT   DM $

100  RBMG4    DM,MLL,MLR,MRR/MR $

101  CHKPNT   MR $

102  LABEL    LBL7 $

103  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,,
              EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

104  SAVE     LUSETD,NOUE,NODLT,NOFRL,NOEED,NOPSDL $

105  COND     ERROR2,NOEED $

106  PURGE    UEVF/NOUE $

107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

108  CHKPNT   USETD,EQDYN,TFPOOL,DLT,FRL,EED,GOD,GMD,UEVF,SILD,PSDL,GPLD $

109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $

111  SAVE     NEIGV $

112  CHKPNT   LAMA,PHIA,MI,OEIGS $

113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

114  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

115  SAVE     CARDNO $

116  COND     ERROR4,NEIGV $

117  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $


118  PARAM    //C,N,MPY/V,N,REPEATF/C,N,1/C,N,-1 $

119  JUMP     LBL13 $
------------------------------------------------------------ Top of DMAP Loop
120  LABEL    LBL13 $

121  PURGE    DUHVC1,DUHVC2,XYPLTFA,OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,OPPC2,
              OQPC2,OUPVC2,OESC2,OEFC2,XYPLTF,PSDF,AUTO,XYPLTR,K2PP,M2PP,
              B2PP,K2DD,M2DD,B2DD,OFPCA,IQP1,IPHIP1,IES1,IEF1,OPPCB,IQP2,
              IPHIP2,IES2,IEF2,ZQPC2,ZUPVC2,ZESC2,ZEFC2,ZQPC1,ZUPVC1,ZESC1,
              ZEFC1/NEVER $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  CASE     CASECC,PSDL/CASEXX/C,N,FREQ/V,N,REPEATF/V,N,NOLOOP $

123  SAVE     REPEATF,NOLOOP $

124  CHKPNT   CASEXX $

125  MTRXIN   CASEXX,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

126  SAVE     NOK2PP,NOM2PP,NOB2PP $

127  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $

128  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $

129  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $

130  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $

131  GKAD     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,    GOD,K2DD,M2DD,
              B2DD/C,N,FREQRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
              V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/    V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/V,N,NOUE/C,N,-1/C,N,-1/    C,N,+1/V,Y,MODACC = -1 $

132  CHKPNT   MDD,GMD,GOD,K2DD,M2DD,B2DD $

133  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASEXX/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,   NOM2PP/
              V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

134  SAVE     NONCUP,FMODE $

135  CHKPNT   MHH,BHH,KHH,PHIDH $

136  COND     ERROR5,NOFRL $

137  COND     ERROR6,NODLT $

138  FRRD     CASEXX,USETD,DLT,FRL,GMD,GOD,KHH,BHH,MHH,PHIDH,DIT/UHVF,PSF,
              PDF,PPF/C,N,DISP/C,N,MODAL/V,N,LUSETD/V,N,MPCF1/V,N,SINGLE/V,N,

              OMIT/V,N,NONCUP/V,N,FRQSET $

139  SAVE     FRQSET $

140  EQUIV    PPF,PDF/NOSET $

141  CHKPNT   PSF,PPF,UHVF,PDF $

142  VDR      CASEXX,EQDYN,USETD,UHVF,PPF,XYCDB,/OUHVC1,/C,N,FREQRESP/C,N,
              MODAL/V,N,NOSORT2/V,N,NOH/V,N,NOP/V,N,FMODE $

143  SAVE     NOH,NOP,NOSORT2 $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
144  COND      LBL16,NOH $
145  COND      LBL16A,NOSORT2 $
146  CHKPNT    OUHVC1 $
147  SDR3      OUHVC1,,,,,/OUHVC2,,,,, $
148  OFP       OUHVC2,,,,,//V,N,CARDNO $
149  SAVE      CARDNO $
150  CHKPNT    OUHVC2 $
151  XYTRAN    XYCDB,OUHVC2,,,,/XYPLTFA/C,N,FREQ/C,N,HSET/V,N,PFILE/V,N,
               CARDNO $
152  SAVE      PFILE,CARDNO $
153  XYPLOT    XYPLTFA // $
154  JUMP      LBL16 $
155  LABEL     LBL16A $
156  OFP       OUHVC1,,,,,//V,N,CARDNO $
157  SAVE      CARDNO $
158  LABEL     LBL16 $
159  COND      LBL14,NOP $
160  PARAM     //C,N,NOT/V,N,NOMOD/V,Y,MODACC $
161  COND      LBDDRM,MODACC $
162  DDR1      UHVF,PHIDH/UDV1F $
163  CHKPNT    UDV1F $

164  DDR2      USETD,UDV1F,PDF,K2DD,B2DD,MDD,PPF,LLL,DM/UDV2F,UEVF,PAF/   C,N,
               FREQRESP/V,N,NOUE/V,N,REACT/V,N,FRQSET $
165  CHKPNT    UDV2F,UEVF,PAF $
166  EQUIV     UDV2F,UDV1F/NOMOD $
167  CHKPNT    UDV1F $
168  EQUIV     UDV1F,UPVC/NOA $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
169  COND     LBLNOA,NOA $

170  SDR1     USETD,,UDV1F,,,GOD,GMD,PSF,KFS,,/UPVC,,QPC/C,N,1/C,N,DYNAMICS $

171  LABEL    LBLNOA $

172  CHKPNT   UPVC,QPC $

173  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,PPF,QPC,UPVC,EST,
              XYCDB,PPF/OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,PUGV/C,N,FREQ/ V,N,
              NOSORT2 $

174  SAVE     NOSORT2 $

175  COND     LBL18,NOSORT2 $

176  SDR3     OPPC1,OQPC1,OUPVC1,OESC1,OEFC1,/OPPC2,OQPC2,OUPVC2,OESC2,
              OEFC2, $

177  JUMP     P2A $

178  LABEL    LBDDRM $

179  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,DYNAMICS $

180  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
              ,IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG/V,N,NOSORT2 $

181  SAVE     NOSORT2 $

182  SDR2     CASEXX,,,,EQDYN,SILD,,,,PPF,,,,XYCDB,PPF/OPPCA,,,,,/C,N,FREQ $

183  EQUIV    OPPCA,OPPC1/MODACC $

184  COND     LBLSORT,NOSORT2 $

185  SDR3     IQP1,IPHIP1,IES1,IEF1,OPPCA,/IQP2,IPHIP2,IES2,IEF2,OPPCB, $

186  EQUIV    OPPCB,OPPC2/MODACC $

187  DDRMM    CASEXX,UHVF,PPF,IPHIP2,IQP2,IES2,IEF2,XYCDB,EST,MPT,DIT/
              ZUPVC2,ZQPC2,ZESC2,ZEFC2, $

188  EQUIV    ZUPVC2,OUPVC2/MODACC/ZQPC2,OQPC2/MODACC/ZESC2,OESC2/MODACC/
              ZEFC2,OEFC2/MODACC $

189  JUMP     P2A $

190  LABEL    LBLSORT $

191  DDRMM    CASEXX,UHVF,PPF,IPHIP1,IQP1,IES1,IEF1,,EST,MPT,DIT/   ZUPVC1,
              ZQPC1,ZESC1,ZEFC1, $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
192  EQUIV    ZUPVC1,OUPVC1/MODACC/ZOPC1,OQPC1/MODACC/ZESC1,OESC1/MODACC/
              ZEFC1,OEFC1/MODACC $

193  JUMP     LBL18 $

194  LABEL    P2A $

195  CHKPNT   OUPVC2,OPPC2,OQPC2,OESC2,OEFC2 $

196  OFP      OPPC2,OQPC2,OUPVC2,OEFC2,OESC2,//V,N,CARDNO $

197  SAVE     CARDNO $

198  XYTRAN   XYCDB,OPPC2,OQPC2,OUPVC2,OESC2,OEFC2/XYPLTF/C,N,FREQ/C,N,PSET/
              V,N,PFILE/V,N,CARDNO $

199  SAVE     PFILE,CARDNO $

200  XYPLOT   XYPLTF// $

201  COND     LBL21,JUMPPLOT $

202  PLOT     PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,,/  PLOTX2/
              V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

203  SAVE     PFILE $

204  LABEL    LBL21 $

205  COND     LBL14,NOPSDL $

206  RANDOM   XYCDB,DIT,PSDL,OUPVC2,OPPC2,OQPC2,OESC2,OEFC2,CASEXX/PSDF,AUTO/
              V,N,NORD $

207  SAVE     NORD $

208  CHKPNT   PSDF,AUTO $

209  COND     LBL14,NORD $


210  XYTRAN   XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
              CARDNO $

211  SAVE     PFILE,CARDNO $

212  XYPLOT   XYPLTR// $

213  JUMP     LBL14 $

214  LABEL    LBL18 $

215  OFP      OUPVC1,OPPC1,OQPC1,OEFC1,OESC1,//V,N,CARDNO $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
216  SAVE     CARDNO $
217  LABEL    LBL14 $
218  COND     FINIS,REPEATF $
219  REPT     LBL13,100 $
220  JUMP     ERROR3 $
221  JUMP     FINIS $
222  LABEL    ERROR3 $
223  PRTPARM  //C,N,-3/C,N,MDLFRRD $
224  LABEL    ERROR2 $
225  PRTPARM  //C,N,-2/C,N,MDLFRRD $
226  LABEL    ERROR1 $
227  PRTPARM  //C,N,-1/C,N,MDLFRRD $
228  LABEL    ERROR4 $
229  PRTPARM  //C,N,-4/C,N,MDLFRRD $
230  LABEL    ERROR5 $
231  PRTPARM  //C,N,-5/C,N,MDLFRRD $
232  LABEL    ERROR6 $
233  PRTPARM  //C,N,-6/C,N,MDLFRRD $
234  LABEL    FINIS $
235  END      $
```

Bottom of DMAP Loop

3.12.2 Description of DMAP Operations for Modal Frequency and Random Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 226 and print error messages if there are no structural elements .

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 226 if no mass matrix is to be assembled.

39. EMA assembles stiffness matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

65. Go to DMAP No. 70 if no multipoint constraints.

66. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

68. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m].$$

71. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

73. Go to DMAP No. 76 if no single-point constraints.

74. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right] .$$

77. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

78. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

80. Go to DMAP No. 85 if no omitted coordinates.

81. SMP1 partitions constrained stiffness matrix.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$

83. SMP2 partitions constrained mass matrix.

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o].$$

86. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

88. Go to DMAP No. 92 if no free-body supports.

89. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right] .$$

91. Go to DMAP No. 94.

93. Go to DMAP No. 102 if no request for mode acceleration data recovery.

95. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

97. Go to DMAP No. 102 if no free-body supports.

98. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}],$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D],$$

and calculates rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

100. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

103. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool, Dynamic Loads Table, Power Spectral Density List, Frequency Response List and Eigenvalue Extraction Data.

105. Go to DMAP No. 224 and print error message if no Eigenvalue Extraction Data.

107. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

110. READ extracts real eigenvalues from the equation

$$[K_{aa} - \lambda M_{aa}]\{u_a\} = 0 ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D_m \phi_{ro} \\ \hline \phi_{ro} \end{array}\right] .$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

116. Go to DMAP No. 228 and print error message if no eigenvalues found.

119. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

120. Beginning of loop for additional sets of direct input matrices.

122. CASE extracts user requests from CASECC for current loop.

125. MTRXIN selects the direct input matrices for the current loop, $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$.

129. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$ and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points introduced for Dynamic analysis.

131. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$ and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$ and $[B_{dd}^2]$.

133. GKAM assembles stiffness, mass, and damping matrices in modal coordinates for use in Frequency Response.

$$[K_{hh}] = [k] + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}],$$

$$[B_{hh}] = [b] + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}],$$

where
$$m_i = \text{modal masses}$$
$$b_i = m_i \; 2\pi \; f_i \; g(f_i)$$
$$k_i = m_i \; 4\pi^2 f_i^2$$

and direct input matrices may be complex.

136. Go to DMAP No. 230 and print error message if no Frequency Response List.

137. Go to DMAP No. 232 and print error message if no Dynamic Loads Table.

138. FRRD forms the dynamic load vectors $\{P_h\}$ and solves for the displacements using the following equation

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K_{hh}]\{u_h\} = \{P_h\}.$$

140. Equivalence $\{P_p\}$ to $\{P_d\}$ if no constraints applied.

142. VDR prepares displacements, sorted by frequency, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

144. Go to DMAP No. 158 if no output request for solution points.

145. Go to DMAP No. 155 if no output request for solution points sorted by extra point or mode number.

147. SDR3 sorts the solution point displacements by extra point or mode number.

148. ØFP formats the requested solution point displacements prepared by SDR3 and places them on the system output file for printing.

151. XYTRAN prepares the input for X-Y plotting of the solution point displacements vs. frequency.

153. XYPLØT prepares requested X-Y plots of the solution point displacements vs. frequency.

154. Go to DMAP No. 158.

156. ØFP formats the requested solution point displacements prepared by VDR and places them on the system output file for printing.

159. Go to DMAP No. 213 if no output request involving dependent degrees of freedom or forces and stresses.

161. Go to DMAP No. 178 if mode acceleration technique not requested.

162. DDR1 transforms the solution vector of displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\}$$

164. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

168. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

169. Go to DMAP No. 171 if no constraints applied.

170. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \quad , \qquad \begin{Bmatrix} u_d \\ -- \\ u_o \end{Bmatrix} = \{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_f + u_e \\ --- \\ u_s \end{Bmatrix} = \{u_n + u_e\} \quad , \qquad \{u_m\} = [G_m^d]\{u_f + u_e\} \quad ,$$

$$\begin{Bmatrix} u_n + u_e \\ --- \\ u_m \end{Bmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

173. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares load vectors (ØPPC1), displacement vectors (ØUPVC1) and single-point forces of constraint (ØQPC1) for output, sorted by frequency.

175. Go to DMAP No. 214 if no output requests sorted by point number of element number.

176. SDR3 prepares requested output sorted by point number or element number.

177. Go to DMAP No. 194 because no mode acceleration requested.

179. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_n\} \quad , \qquad \left\{\begin{array}{c}\phi_n \\ \hline \phi_o\end{array}\right\} = \{\phi_f + u_e\}$$

$$\left\{\begin{array}{c}\phi_f + u_e \\ \hline \phi_s\end{array}\right\} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\left\{\begin{array}{c}\phi_n + u_e \\ \hline \phi_m\end{array}\right\} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

180. SDR2 calculates element forces (IEF1) and stresses (IES1) and prepares eigenvectors (IPHIP1) and single-point forces of constraint (IQP1) for output sorted by frequency.

182. SDR2 prepares load vectors for output (ØPPCA) sorted by frequency.

183. Equivalence ØPPCA to ØPPC1 if mode acceleration requested.

184. Go to DMAP No. 190 if no output requested by point number or element number sort.

185. SDR3 prepares requested output sorted by point number or element number.

186. Equivalence ØPPCB to ØPPC2 if mode acceleration requested.

187. DDRMM prepares a subset of the element forces (ZEFC2) and stresses (ZESC2), and displacement vectors (ZUPVC2) and single-point forces of constraint (ZQPC2) solutions for output by point number or element number sort.

188. Equivalence ZUPVC2 to ØUPVC2, ZQPC2 to ØQPC2, ZESC2 to ØESC2, and ZEFC2 to ØEFC2 if mode acceleration requested.

189. Go to DMAP No. 194 because requested output is sorted by point number or element number.

191. DDRMM prepares a subset of the element forces (ZEFC1) and stresses (ZESC1) and displacement vectors (ZUPVC1) and single-point forces of constraint (ZQPC1) solutions for output.

192. Equivalence ZUPVC1 to ØUPVC1, ZQPC1 to ØQPC1, ZESC1 to ØESC1, and ZEFC1 to ØEFC1 if mode accelerations are requested.

193. Go to DMAP No. 214 because requested output is not sorted by point number or element number.

MODAL FREQUENCY AND RANDOM RESPONSE

196. ØFP formats the requested output prepared by SDR3 (no mode acceleration) or DDRMM (with mode acceleration) and places it on the system output file for printing.

198. XYTRAN prepares the input for requested X-Y plots.

200. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads or single-point forces of constraint vs. frequency.

201. Go to DMAP No. 204 if no deformed structure plots are requested.

202. PLØT generates all requested deformed structure and contour plots.

205. Go to DMAP No. 217 if no power spectral density functions or autocorrelation functions requested.

206. RANDØM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTØ) using the previously calculated frequency response.

209. Go to DMAP No. 213 if no X-Y plots of RANDØM calculations requested.

210. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

212. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.

214. Go to DMAP No. 213 because there are no frequency response output requests sorted by frequency.

215. ØFP formats the frequency response output requests prepared by SDR2 and places them on the system output file for printing.

218. Go to DMAP No. 234 if no additional sets of direct input matrices need to be processed.

219. Go to DMAP No. 120 if additional sets of direct input matrices need to be processed.

220. Go to DMAP No. 222 and print error message if more than 100 loops.

221. Go to DMAP No. 234 and make normal exit.

223. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

225. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

227. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

229. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

231. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

233. MØDAL FREQUENCY AND RANDØM RESPØNSE ERRØR MESSAGE NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

3.12.3 Automatic Output for Modal Frequency and Random Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.12.4 Case Control Deck and Parameters for Modal Frequency and Random Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Frequency and Random Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Printed output and X-Y plots that may be requested is the same as that described under Direct Frequency and Random Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The following plotter output is also available in Modal Frequency and Random Response:

1. Deformed shapes of the structural model for selected frequency intervals.
2. Contour plots of stress and displacement for selected frequency intervals.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Frequency and Random Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

3.12.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.5).

3.13 MODAL TRANSIENT RESPONSE

3.13.1 DMAP Sequence for Modal Transient Response

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 12

   LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.12 MODAL TRANSIENT RESPONSE ANALYSIS - SERIES 0 $

    2  FILE     LAMA=APPEND/PHIA=APPEND/UHVT=APPEND/TOL=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET $

    5  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  CHKPNT   ECT $

    8  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

    9  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   10  COND     P1,NOPCDB $

   11  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   12  SAVE     NSIL,JUMPPLOT $

   13  PRTMSG   PLTSETX// $

   14  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   15  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   16  COND     P1,JUMPPLOT $

   17  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   18  SAVE     JUMPPLOT,PLTFLG,PFILE $


   19  PRTMSG   PLOTX1// $

   20  LABEL    P1 $

   21  CHKPNT   PLTPAR,GPSETS,ELSETS $

   22  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

   23  CHKPNT   SLT,GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  TA1     ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
            NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE    NOGENL,NOSIMP,GENEL $

26  COND    ERROR1,NOSIMP $

27  PURGE   OGPST/GENEL $

28  CHKPNT  EST,GPECT,GEI,OGPST $

29  PARAM   //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM   //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG     EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
            N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
            CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
            CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE    NOKGGX,NOMGG $

33  CHKPNT  KELM,KDICT,MELM,MDICT $

34  COND    JMPKGGX,NOKGGX $

35  EMA     GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT  KGGX,GPST $

37  LABEL   JMPKGGX $

38  COND    ERROR1,NOMGG $

39  EMA     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT  MGG $

41  COND    LGPWG,GRDPNT $


42  GPWG    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

43  OFP     OGPWG,,,,,// $

44  LABEL   LGPWG $

45  EQUIV   KGGX,KGG/NOGENL $

46  CHKPNT  KGG $

47  COND    LBL11,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3    GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

49  CHKPNT  KGG $

50  LABEL   LBL11 $

51  PARAM   //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

52  GP4     CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
            V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
            N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

53  SAVE    MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2,NSKIP,REPEAT,NOL,NOA $

54  PARAM   //C,N,AND/V,N,NOSR/V,N,REACT/V,N,SINGLE $

55  PURGE   GM,GMD/MPCF1/GO,GOD/OMIT/KFS,PST/SINGLE/QP/NOSR/KLR,KRR,MLR,MR,
            MRR,DM/REACT $

56  CHKPNT  KRR,KLR,DM,MLR,MRR,MR,GM,RG,GO,KFS,PST,QP,USET,GOD,GMD,ASET $

57  COND    LBL4,GENEL $

58  GPSP    GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

59  SAVE    NOGPST $

60  COND    LBL4,NOGPST $

61  OFP     OGPST,,,,,// $

62  LABEL   LBL4 $

63  EQUIV   KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

64  CHKPNT  KNN,MNN $

65  COND    LBL2,MPCF1 $

66  MCE1    USET,RG/GM $


67  CHKPNT  GM $

68  MCE2    USET,GM,KGG,MGG,,/KNN,MNN,, $

69  CHKPNT  KNN,MNN $

70  LABEL   LBL2 $

71  EQUIV   KNN,KFF/SINGLE/MNN,MFF/SINGLE $

72  CHKPNT  KFF,MFF $
```

```
RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 12

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


73  COND     LBL3,SINGLE $

74  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $

75  CHKPNT   KFS,KFF,MFF $

76  LABEL    LBL3 $

77  EQUIV    KFF,KAA/OMIT $

78  EQUIV    MFF,MAA/OMIT $

79  CHKPNT   KAA,MAA $

80  COND     LBL5,OMIT $

81  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

82  CHKPNT   GO,KAA $

83  SMP2     USET,GO,MFF/MAA $

84  CHKPNT   MAA $

85  LABEL    LBL5 $

86  EQUIV    KAA,KLL/REACT $

87  CHKPNT   KLL $

88  COND     LBL6,REACT $

89  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

90  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

91  JUMP     LBL8 $

92  LABEL    LBL6 $


93  COND     LBL7,MODACC $

94  LABEL    LBL8 $

95  RBMG2    KLL/LLL $

96  CHKPNT   LLL $

97  COND     LBL7,REACT $

98  RBMG3    LLL,KLR,KRR/DM $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  CHKPNT   DM $
100  RBMG4    DM,MLL,MLR,MRR/MR $
101  CHKPNT   MR $
102  LABEL    LBL7 $
103  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,,,NLFT,TRL,
              EED ,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
              V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $
104  SAVE     LUSETD,NODLT,NONLFT,NOTRL,NOUE,NOEED $
105  COND     ERROR2,NOEED $
106  PURGE    UEVT/NOUE/PNLH/NONLFT $
107  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $
108  CHKPNT   USETD,EQDYN,TFPOOL,DLT,TRL,EED,GOD,GMD,UEVT,NLFT,PNLH,SILD,
              GPLD $
109  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $
110  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
              NEIGV $
111  SAVE     NEIGV $
112  CHKPNT   LAMA,PHIA,MI,OEIGS $
113  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
114  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $
115  SAVE     CARDNO $
116  COND     ERROR4,NEIGV $

117  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $
118  SAVE     NOK2PP,NOM2PP,NOB2PP $
119  PURGE    K2DD/NOK2PP/M2DD/NOM2PP/B2DD/NOB2PP $
120  PARAM    //C,N,AND/V,N,MDEMA/V,N,NOUE/V,N,NOM2PP $
121  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA/MAA,MDD/MDEMA $
122  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD,MDD $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  GKAD     USETD,GM,GO,,,MAA,,K2PP,M2PP,B2PP/,,MDD,GMD,   GOD,K2DD,M2DD,
              B2DD/C,N,TRANRESP/C,N,DISP/C,N,MODAL/C,N,0.0/ C,N,0.0/C,N,0.0/
              V,N,NOK2PP/V,N,NOM2PP/V,N,NOB2PP/   V,N,MPCF1/V,N,SINGLE/V,N,
              OMIT/V,N,NOUE/C,N,-1/C,N,-1/   C,N,+1/V,Y,MODACC = -1 $

124  CHKPNT   MDD,GMD,GOD,K2DD,M2DD,B2DD $

125  GKAM     USETD,PHIA,MI,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/
              V,N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0.0/C,Y,HFREQ=0.0/V,N,  NOM2PP/
              V,N,NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE $

126  SAVE     NONCUP,FMODE $

127  CHKPNT   MHH,BHH,KHH,PHIDH $

128  COND     ERRORS,NOTRL $

129  PARAM    //C,N,ADD/V,N,NEVER/C,N,1/C,N,0 $

130  PARAM    //C,N,MPY/V,N,REPEATT/C,N,1/C,N,-1 $

131  JUMP     LBL13 $
-------------------------------------------------------------------- Top of DMAP Loop
132  LABEL    LBL13 $

133  PURGE    PNLH,OUHV1,OPNL1,OUHV2,OPNL2,XYPLTTA,OPP1,OQP1,OUPV1,OES1,OEF1,
              OPP2,OQP2,OUPV2,OES2,OEF2,PLOTX2,XYPLTT,OPPA,IQP1,IPHIP1,IES1,
              IEF1,OPPB,IQP2,IPHIP2,IES2,IEF2,ZQP2,ZUPV2,ZES2,ZEF2/NEVER $

134  CASE     CASECC,/CASEXX/C,N,TRAN/V,N,REPEATT/V,N,NOLOOP $

135  SAVE     REPEATT,NOLOOP $

136  CHKPNT   CASEXX $

137  PARAM    //C,N,MPY/V,N,NCOL/C,N,0/C,N,1 $

138  TRLG     CASEXX,USETD,DLT,SLT,BGPDT,SIL,CSTM,TRL,DIT,GMD,GOD,PHIDH, EST,
              MGG/PPT,PST,PDT,PD,PH,TOL/V,N,NOSET/V,N,PDEPDO/V,N,NCOL $


139  SAVE     PDEPDO,NOSET $

140  CHKPNT   PPT,PST,PDT,PD,PH,TOL $

141  EQUIV    PD,PDT/PDEPDO/PPT,PST/NOSET $

142  CHKPNT   PDT $

143  TRD      CASEXX,TRL,NLFT,DIT,KHH,BHH,MHH,PH/UHVT,PNLH/C,N,MODAL/ V,N,
              NOUE/V,N,NONCUP/V,N,NCOL/C,Y,ISTART $

144  SAVE     NCOL $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
145  CHKPNT   UHVT,PNLH $
146  VDR      CASEXX,EQDYN,USETD,UHVT,TOL,XYCDB,PNLH/OUHV1,OPNL1/ C,N,
              TRANRESP/C,N,MODAL/C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE $
147  SAVE     NOH,NOP $
148  CHKPNT   OUHV1,OPNL1 $
149  COND     LBL16,NOH $
150  SDR3     OUHV1,OPNL1,,,,/OUHV2,OPNL2,,,, $
151  OFP      OUHV2,OPNL2,,,,//V,N,CARDNO $
152  SAVE     CARDNO $
153  CHKPNT   OPNL2,OUHV2 $
154  XYTRAN   XYCDB,OUHV2,OPNL2,,,/XYPLTTA/C,N,TRAN/C,N,HSET/V,N,PFILE/V,N,
              CARDNO $
155  SAVE     PFILE,CARDNO $
156  XYPLOT   XYPLTTA// $
157  LABEL    LBL16 $
158  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
159  COND     LBL15,PJUMP $
160  PARAM    //C,N,NOT/V,N,NOMOD/V,Y,MODACC $
161  PARAM    //C,N,AND/V,N,MPJUMP/V,Y,MODACC/V,N,JUMPPLOT $
162  COND     LBDDRM,MPJUMP $
163  DDR1     UHVT,PHIDH/UDV1T $
164  CHKPNT   UDV1T $
165  COND     LBLMOD,MODACC $
166  DDR2     USETD,UDV1T,PDT,K2DD,B2DD,MDD,,LLL,DM/UDV2T,UEVT,PAF/  C,N,
              TRANRESP/V,N,NOUE/V,N,REACT/C,N,0 $
167  CHKPNT   UDV2T,UEVT,PAF $
168  EQUIV    UDV2T,UDV1T/NOMOD $
169  CHKPNT   UDV1T $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
170  LABEL    LBLMOD $
171  EQUIV    UDV1T,UPV/NOA $
172  COND     LBL14,NOA $
173  SDR1     USETD,,UDV1T,,,GOD,GMD,PST,KFS,,/UPV,,QP/C,N,1/C,N,DYNAMICS $
174  LABEL    LBL14 $
175  CHKPNT   UPV,QP $
176  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,BGPDT,TOL,QP,UPV,EST,XYCDB,
              PPT/OPP1,OQP1,OUPV1,OES1,OEF1,PUGV/C,N,TRANRESP $
177  SDR3     OPP1,OQP1,OUPV1,OES1,OEF1,/OPP2,OQP2,OUPV2,OES2,OEF2, $
178  JUMP     P2A $
179  LABEL    LBDDRM $
180  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIPH,,QPH/C,N,1/C,N,REIG $
181  SDR2     CASEXX,CSTM,MPT,DIT,EQDYN,SILD,,,,LAMA,QPH,PHIPH,EST,XYCDB,/
              ,IQP1,IPHIP1,IES1,IEF1,/C,N,MMREIG $
182  SDR2     CASEXX,,,,EQDYN,SILD,,,,TOL,,,,XYCDB,PPT/OPPA,,,,,/C,N,
              TRANRESP $
183  SDR3     OPPA,IQP1,IPHIP1,IES1,IEF1,/OPPB,IQP2,IPHIP2,IES2,IEF2, $
184  EQUIV    OPPB,OPP2/MODACC $
185  DDRMM    CASEXX,UHVT,TOL,IPHIP2,IQP2,IES2,IEF2,,EST,MPT,DIT/   ZUPV2,
              ZQP2,ZES2,ZEF2, $
186  EQUIV    ZUPV2,OUPV2/MODACC/ZQP2,OQP2/MODACC/ZEF2,OEF2/MODACC/ZES2,OES2/
              MODACC $
187  LABEL    P2A $

188  CHKPNT   OPP2,OQP2,OUPV2,OES2,OEF2 $
189  OFP      OUPV2,OPP2,OQP2,OEF2,OES2,//V,N,CARDNO $
190  SAVE     CARDNO $
191  COND     P2,JUMPPLOT $
192  PLOT     PLTPAR,GPSETS,ELSETS,CASEXX,BGPDT,EQEXIN,SIL,,PUGV,,/PLOTX2/
              V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 12

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
193  SAVE      PFILE $
194  PRTMSG    PLOTX2// $
195  LABEL     P2 $
196  XYTRAN    XYCDB,OPP2,OQP2,OUPV2,OES2,OEF2/XYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $
197  SAVE      PFILE,CARDNO $
198  XYPLOT    XYPLTT// $
199  LABEL     LBL15 $
200  COND      FINIS,REPLATT $
201  REPT      LBL13,100 $
------------------------------------------- Bottom of DMAP Loop
202  JUMP      ERROR3 $
203  JUMP      FINIS $
204  LABEL     ERROR3 $
205  PRTPARM   //C,N,-3/C,N,MDLTRD $
206  LABEL     ERROR2 $
207  PRTPARM   //C,N,-2/C,N,MDLTRD $
208  LABEL     ERROR1 $
209  PRTPARM   //C,N,-1/C,N,MDLTRD $
210  LABEL     ERROR4 $
211  PRTPARM   //C,N,-4/C,N,MDLTRD $
212  LABEL     ERROR5 $

213  PRTPARM   //C,N,-5/C,N,MDLTRD $
214  LABEL     FINIS $
215  END       $
```

3.13.2 Description of DMAP Operations for Modal Transient Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots are requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 208 and print error message if there are no structural elements.

31. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K_{gg}^{x}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 208 and print error message if no mass matrix is to be assembled.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K_{gg}^{x}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to stiffness matrix $[K_{gg}^{x}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

57. Go to DMAP No. 62 if general elements present.

58. GPSP determines if possible grid point singularities remain.

60. Go to DMAP No. 62 if no grid point singularities remain.

61. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

63. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

$$[\phi_{ao}] = \begin{bmatrix} D_m \phi_{ro} \\ \phi_{ro} \end{bmatrix} ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

114. ØFP formats the summary of eigenvalues (LAMA) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

116. Go to DMAP No. 210 and print error message if no eigenvalues found.

117. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$.

121. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied, and $[M_{aa}]$ to $[M_{dd}]$ if no direct input mass matrices and no extra points.

123. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$ and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$ and $[B^2_{dd}]$.

125. GKAM assembles stiffness mass and damping matrices in modal coordinates for use in Transient Response

$$[K_{hh}] = [k] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] ,$$

$$[M_{hh}] = [m] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] ,$$

$$[B_{hh}] = [b] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] ,$$

where

$$m_i = \text{modal masses}$$

$$b_i = m_i \, 2\pi \, f_i \, g(f_i)$$

$$k_i = m_i \, 4\pi^2 \, f_i^2$$

and all matrices are real.

128. Go to DMAP No. 212 and print error message if no Transient Response List.

131. Go to next DMAP instruction if cold start or modified restart. LBL13 will be altered by the Executive System to the proper location inside the loop for unmodified starts within the loop.

132. Beginning of loop for additional dynamic load sets.

134. CASE extracts user requests from CASECC for current loop.

138. TRLG generates matrices of loads versus time. $\{P_p^t\}$, $\{P_s^t\}$, and $\{P_d^t\}$ are generated with one column per output time step. $\{P_d\}$ and $\{P_h\}$ are generated with one column per solution time step, and the Transient Output List (TØL) is a list of output time steps.

141. Equivalence $\{P_d\}$ to $\{P_d^t\}$ if the output times are the same as the solution times and $\{P_d^t\}$ to $\{P_p^t\}$ if the d and p sets are the same.

143. TRD forms the linear, $\{P_d\}$, and nonlinear, $\{P_d^{n\ell}\}$, dynamic load vectors and integrates the equations of motion using the standard starting procedure over specified time periods to solve for the displacements, velocities and accelerations, using the following equation

$$[M_{hh}p^2 + B_{hh}p + K_{hh}]\{u_h\} = \{P_h\} + \{P_h^{n\ell}\} \quad .$$

146. VDR prepares displacements, velocities and accelerations, sorted by time step, for output using only the extra points introduced for dynamic analysis and modal coordinates (solution points).

149. Go to DMAP No. 157 if no output request for the solution points.

150. SDR3 sorts the solution point displacements, velocities, accelerations and nonlinear load vectors by point number.

151. ØFP formats the requested solution point displacements, velocities, accelerations and non-linear load vectors prepared by SDR3 and places them on the system output file for printing.

154. XYTRAN prepares the input for X-Y plotting of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

156. XYPLØT prepares requested X-Y plots of the solution point displacements, velocities, accelerations and nonlinear load vectors vs time.

159. Go to DMAP No. 199 if no output request involving dependent degrees of freedom, forces and stresses, or deformed structure plot.

163. DDR1 transforms the solution vector displacements from modal to physical coordinates

$$\{u_d\} = [\phi_{dh}]\{u_h\} \quad .$$

165. Go to DMAP No. 170 if mode acceleration technique not requested.

166. DDR2 calculates an improved displacement vector using the mode acceleration technique, if requested.

171. Equivalence $\{u_d\}$ to $\{u_p\}$ if no constraints applied.

172. Go to DMAP No. 174 if no constraints applied.

173. SDR1 recovers dependent components of displacements

$$\{u_o\} = [G_o^d]\{u_d\} \qquad \begin{Bmatrix} u_d \\ --- \\ u_o \end{Bmatrix} = \{u_f + u_e\} \quad .$$

$$\begin{Bmatrix} u_f + u_e \\ ---- \\ u_s \end{Bmatrix} = \{u_n + u_e\} \ , \qquad \{u_m\} = [G_m^d]\{u_n + u_e\} \quad ,$$

$$\begin{Bmatrix} u_n + u_e \\ ---- \\ u_m \end{Bmatrix} = \{u_p\}$$

and recovers single-point forces of constraint $\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\}$.

176. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPP1), displacement, velocity and acceleration vectors (ØUPV1) and single-point forces of constraint (ØQP1) for output and the translation components of the displacement vector (PUGV) sorted by time step.

177. SDR3 prepares requested output sorted by point number or element number.

178. Go to DMAP No. 187 because no mode acceleration requested.

180. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o^d]\{\phi_h\} \ , \qquad \begin{Bmatrix} \phi_h \\ --- \\ \phi_o \end{Bmatrix} = \{\phi_f + u_e\}$$

$$\begin{Bmatrix} \phi_f + u_e \\ ---- \\ \phi_s \end{Bmatrix} = \{\phi_n + u_e\} \qquad \{\phi_m\} = [G_m^d]\{\phi_n + u_e\}$$

$$\begin{Bmatrix} \phi_n + u_e \\ ---- \\ \phi_m \end{Bmatrix} = \{\phi_g + u_e\} = \{\phi_p\}$$

and recovers single-point forces of constraint

$$\{q_s\} = [K_{fs}]^T\{\phi_f\} \quad .$$

181. SDR2 calculates element forces (IEF1) and stresses (IES1) and prepares eigenvectors (IPHIP1) and single-point forces of constraint (IQP1) for output sorted by time step.

182. SDR2 prepares load vectors for output (ØPPA) sorted by time step.

183. SDR3 prepares requested output sorted by point number or element number.

184. Equivalence ØPPB to ØPP2 if mode acceleration requested.

185. DDRMM prepares a subset of the element forces (ZEF2) and stresses (ZES2), displacement vectors (ZUPV2) and single-point forces of constraint (ZQP2) solutions for output sorted by point number of element number.

186. Equivalence ZUPV2 to ØUPV2, ZQP2 to ØQP2, ZES2 to ØES2, and ZEF2 to ØEF2 if mode acceleration requested.

189. ØFP formats requested output prepared by SDR3 (no mode acceleration) or DDRMM (with mode acceleration) and places it on the system output file for printing.

191. Go to DMAP No. 195 if no deformed structure plots requested.

192. PLØT prepares all requested deformed structure and contour plots.

194. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

196. XYTRAN prepares the input for requested X-Y plots.

198. XYPLØT prepares requested X-Y plots of displacements, velocities, accelerations, forces, stresses, loads or single-point forces of constraint vs time.

200. Go to DMAP No. 214 if no additional dynamic load sets need to be processed.

201. Go to DMAP No. 132 if additional dynamic load sets need to be processed.

202. Go to DMAP No. 204 and print error message if more than 100 loops.

203. Go to DMAP No. 214 and make normal exit.

205. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

207. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

209. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

211. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

213. MØDAL TRANSIENT RESPØNSE ERRØR MESSAGE NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.13.3 Automatic Output for Modal Transient Response

The Eigenvalue Summary Table and the Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues extracted are included even though not all are used in the modal formulation.

3.13.4 Case Control Deck and Parameters for Modal Transient Response

The following items related to subcase definition and data selection must be considered in addition to the list presented with Direct Transient Response:

1. METHØD must appear above the subcase level to select an EIGR card that exists in the Bulk Data Deck.
2. All of the eigenvectors used in the modal formulation must be determined in a single execution.
3. An SPC set must be selected above the subcase level unless the model is a free body or all constraints are specified on GRID cards, Scalar Connection cards or with General Elements.
4. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

Output that may be requested is the same as that described under Direct Transient Response. Output for SØLUTIØN points will have the modal coordinates identified by the mode number determined in Real Eigenvalue Analysis.

The eigenvectors used in the modal formulation may be obtained for the SØLUTIØN points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis rigid format or by making a modified restart using the Normal Mode Analysis rigid format.

The following parameters are used in Modal Transient Response:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation.

6. MØDACC - optional - A positive integer value of this parameter causes the Dynamic Data Recovery module to use the mode acceleration method. Not recommended for use in hydroelastic problems.

7. ISTART - optional - A positive value of this parameter will cause the TRD module to use the second (or alternate) starting method (see Section 11.3 of the Theoretical Manual). The alternate starting method is recommended when initial accelerations are significant and when the mass matrix is non-singular.

3.13.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.14 NORMAL MODES WITH DIFFERENTIAL STIFFNESS

3.14.1 DMAP Sequence for Normal Modes with Differential Stiffness

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 13

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

  1  BEGIN     NO.13 NORMAL MODES WITH DIFFERENTIAL STIFFNESS - SERIES 0 $

  2  FILE      LAMA=APPEND/PHIA=APPEND $

  3  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

  4  SAVE      LUSET $

  5  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

  6  GP2       GEOM2,EQEXIN/ECT $

  7  CHKPNT    ECT $

  8  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  9  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

 10  COND      P1,NOPCDB $

 11  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
               JUMPPLOT=-1 $

 12  SAVE      NSIL,JUMPPLOT $

 13  PRTMSG    PLTSETX// $

 14  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

 15  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

 16  COND      P1,JUMPPLOT $

 17  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
               NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

 18  SAVE      JUMPPLOT,PLTFLG,PFILE $


 19  PRTMSG    PLOTX1// $

 20  LABEL     P1 $

 21  CHKPNT    PLTPAR,GPSETS,ELSETS $

 22  GP3       GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

 23  CHKPNT    SLT,GPTT $
```

RIGID FORMAT DMAP LISTING
SERIES U

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  TA1     ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
            NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

25  SAVE    NOSIMP,NOGENL,GENEL $

26  COND    ERROR1,NOSIMP $

27  PURGE   OGPST/GENEL $

28  CHKPNT  EST,GPECT,GEI,OGPST $

29  PARAM   //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

30  PARAM   //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

31  EMG     EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
            N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
            CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
            CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

32  SAVE    NOKGGX,NOMGG $

33  CHKPNT  KELM,KDICT,MELM,MDICT $

34  COND    JMPKGG,NOKGGX $

35  EMA     GPECT,KDICT,KELM/KGGX,GPST $

36  CHKPNT  KGGX,GPST $

37  LABEL   JMPKGG $

38  COND    ERROR5,NOMGG $

39  EMA     GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

40  CHKPNT  MGG $

41  COND    LBL1,GRDPNT $


42  GPWG    BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

43  OFP     OGPWG,,,,,// $

44  LABEL   LBL1 $

45  EQUIV   KGGX,KGG/NOGENL $

46  CHKPNT  KGG $

47  COND    LBL11,NOGENL $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  SMA3     GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

49  CHKPNT   KGG $

50  LABEL    LBL11 $

51  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

52  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

53  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

54  COND     ERROR6,NOL $

55  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

56  PURGE    GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS/SINGLE/  QG/
             NOSR $

57  CHKPNT   GM,RG,GO,KOO,LOO,PO,UOOV,RUOV,YS,PS,KFS,KSS,USET,ASET,QG $

58  COND     LBL4D,REACT $

59  JUMP     ERROR2 $

60  LABEL    LBL4D $

61  COND     LBL4,GENEL $

62  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

63  SAVE     NOGPST $

64  COND     LBL4,NOGPST $

65  OFP      OGPST,,,,,,// $

66  LABEL    LBL4 $


67  EQUIV    KGG,KNN/MPCF1 $

68  CHKPNT   KNN $

69  COND     LBL2,MPCF2 $

70  MCE1     USET,RG/GM $

71  CHKPNT   GM $

72  MCE2     USET,GM,KGG,,,/KNN,,, $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  CHKPNT   KNN $

74  LABEL    LBL2 $

75  EQUIV    KNN,KFF/SINGLE $

76  CHKPNT   KFF $

77  COND     LBL3,SINGLE $

78  SCE1     USET,KNN,,,/KFF,KFS,KSS,,, $

79  CHKPNT   KFS,KSS,KFF $

80  LABEL    LBL3 $

81  EQUIV    KFF,KAA/OMIT $

82  CHKPNT   KAA $

83  COND     LBL5,OMIT $

84  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

85  CHKPNT   GO,KAA,KOO,LOO $

86  LABEL    LBL5 $

87  RBMG2    KAA/LLL $

88  CHKPNT   LLL $

89  SSG1     SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/ V,N,
             LUSET/C,N,1 $

90  CHKPNT   PG $

91  EQUIV    PG,PL/NOSET $

92  CHKPNT   PL $


93  COND     LBL10,NOSET $

94  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $

95  CHKPNT   PO,PS,PL $

96  LABEL    LBL10 $

97  SSG3     LLL,KAA,PL,LOO,KOO,PO/ULV,UOOV,RULV,RUOV/V,N,OMIT/V,Y,IRES=-1/
             C,N,1/V,N,EPSI $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  SAVE      EPSI $

 99  CHKPNT    ULV,UOOV,RULV,RUOV $

100  COND      LBL9,IRES $

101  MATGPR    GPL,USET,SIL,RULV//C,N,L $

102  MATGPR    GPL,USET,SIL,RUOV//C,N,O $

103  LABEL     LBL9 $

104  SDR1      USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/C,N,1/C,N,
               BKLO $

105  CHKPNT    UGV,QG,PGG $

106  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
               OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,BKLO $

107  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

108  OFP       OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $

109  SAVE      CARDNO $

110  COND      P2,JUMPPLOT $

111  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
               PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

112  SAVE      PFILE $

113  PRTMSG    PLOTX2// $

114  LABEL     P2 $

115  TA1       ECT,EPT,BGPDT,SIL,GPDT,CSTM/X1,X2,ECPT,GPCT/V,N,LUSET/  V,N,
               NOSIMP/C,N,0/V,N,NOGENL/V,N,GENEL $


116  DSMG1     CASECC,GPTT,SIL,EDT,UGV,CSTM,MPT,ECPT,GPCT,DIT/KDGG/  V,N,
               DSCOSET $

117  SAVE      DSCOSET $

118  CHKPNT    KDGG $

119  EQUIV     KDGG,KDNN/MPCF2 / MGG,MNN/MPCF2 $

120  CHKPNT    KDNN,MNN $

121  COND      LBL2D,MPCF2 $
```

RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
122  MCE2     USET,GM,KDGG,MGG,,/KDNN,MNN,, $

123  CHKPNT   KDNN,MNN $

124  LABEL    LBL2D $

125  EQUIV    KDNN,KDFF/SINGLE / MNN,MFF/SINGLE $

126  CHKPNT   KDFF,MFF $

127  COND     LBL3D,SINGLE $

128  SCE1     USET,KDNN,MNN,,/KDFF,KDFS,KDSS,MFF,, $

129  CHKPNT   KDFF,KDFS,KDSS,MFF $

130  LABEL    LBL3D $

131  EQUIV    KDFF,KDAA/OMIT / MFF,MAA/OMIT $

132  CHKPNT   KDAA,MAA $

133  COND     LBL5D,OMIT $

134  SMP2     USET,GO,KDFF/KDAA $

135  SMP2     USET,GO,MFF/MAA $

136  CHKPNT   KDAA,MAA $

137  LABEL    LBL5D $

138  PARAM    //C,N,ADD/V,N,DSCOSET/C,N,-1/C,N,0 $

139  EQUIV    PL,PBL/DSCOSET/PS,PBS/DSCOSET/YS,YBS/DSCOSET/UOOV,UBOOV/
              DSCOSET $

140  CHKPNT   PBL,PBS,YBS,UBOOV $

141  PARAM    //C,N,MPY/V,N,NOSKIP/C,N,0/C,N,0 $


142  DSMG2    MPT,KAA,KDAA,KFS,KDFS,KSS,KDSS,PL,PS,YS,UOOV/KBLL,KBFS,KBSS,
              PBL,PBS,YBS,UBOOV/V,N,NOSKIP/ V,N,REPEATD/ V,N,DSCOSET $

143  SAVE     NOSKIP,REPEATD $

144  CHKPNT   KBLL,KBFS,KBSS,PBL,PBS,YBS,UBOOV $

145  RBMG2    KBLL/LBLL/V,N,POWER/V,N,DET $

146  SAVE     DET,POWER $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
147  CHKPNT   LBLL $

148  PRTPARM  //C,N,0/C,N,DET $

149  PRTPARM  //C,N,0/C,N,POWER $

150  SSG3     LBLL,KBLL,PBL,,,/UBLV,,RUBLV,/C,N,-1/V,Y,IRES/V,N,NDSKIP/  V,N,
              EPSI $

151  SAVE     EPSI $

152  CHKPNT   UBLV,RUBLV $

153  COND     LBL9D,IRES $

154  MATGPR   GPL,USET,SIL,RUBLV//C,N,L $

155  LABEL    LBL9D $

156  SDR1     USET,,UBLV,UBOOV,YBS,GO,GM,PBS,KBFS,KBSS,/UBGV,,QBG/V,N,NDSKIP/
              C,N,DS1 $

157  CHKPNT   UBGV,QBG $

158  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QBG,UBGV,EST,,/,
              OQBG1,OUBGV1,OESB1,OEFB1,PUBGV1/C,N,DS1 $

159  OFP      OQBG1,OUBGV1,OESB1,OEFB1,,//V,N,CARDNO $

160  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
              LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
              N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $

161  SAVE     NOEED $

162  COND     ERROR3,NOEED $

163  CHKPNT   EED $

164  PARAM    //C,N,MPY/V,N,NEIGV/C,N,1/C,N,-1 $

165  READ     KBLL,MAA,,,EED,USET,CASECC/LAMA,PHIA,,OEIGS/C,N,MODES/ V,N,
              NEIGV/C,N,3 $

166  SAVE     NEIGV $

167  CHKPNT   LAMA,PHIA,OEIGS $

168  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

169  SAVE     CARDNO $
```

RIGID FORMAT DMAP LISTING
SERIES Q

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
170  COND      ERROR4,NEIGV $

171  SDR1      USET,,PHIA,,,GO,GM,,KDFS,,/PHIG,,BQG/C,N,1/C,N,REIG $

172  CHKPNT    PHIG,BQG $

173  CASE      CASECC,/CASEXX/C,N,TRANRESP/V,N,KEPEAT=3/V,N,LOOP $

174  SDR2      CASEXX,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDT,LAMA,BQG,PHIG,EST,,/,
               OBQG1,OPHIG,OBES1,OBEF1,PPHIG/C,N,REIG $

175  OFP       OPHIG,OBQG1,OBEF1,OBES1,,//V,N,CARDNO $

176  SAVE      CARDNO $

177  COND      P3,JUMPPLOT $

178  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,PPHIG,GPECT,
               OBES1/PLOTX3/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PFILE $

179  SAVE      PFILE $

180  PRTMSG    PLOTX3// $

181  LABEL     P3 $

182  JUMP      FINIS $

183  LABEL     ERROR1 $

184  PRTPARM   //C,N,-1/C,N,NMDS $

185  LABEL     ERROR2 $

186  PRTPARM   //C,N,-2/C,N,NMDS $

187  LABEL     ERROR3 $

188  PRTPARM   //C,N,-3/C,N,NMDS $


189  LABEL     ERROR4 $

190  PRTPARM   //C,N,-4/C,N,NMDS $

191  LABEL     ERROR5 $

192  PRTPARM   //C,N,-5/C,N,NMDS $

193  LABEL     ERROR6 $

194  PRTPARM   //C,N,-6/C,N,NMDS $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 13

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
195  LABEL    FINIS $

196  END      $
```

3.14.2 Description of DMAP Operations for Normal Modes with Differential Stiffness.

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

6. GP2 generates Element Connection Table with internal indices.

10. Go to DMAP No. 20 if no plot output is requested.

11. PLTSET transforms user input into a form used to drive structure plotter.

13. PRTMSG prints error messages associated with structure plotter.

16. Go to DMAP No. 20 if no undeformed structure plots requested.

17. PLØT generates all requested undeformed structure plots.

19. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

22. GP3 generates Static Loads Table and Grid Point Temperature Table.

24. TA1 generates element tables for use in matrix assembly and stress recovery.

26. Go to DMAP No. 183 and print error message if no elements have been defined.

31. EMG generates structural element matrix stiffness and mass tables and dictionaries for later assembly.

34. Go to DMAP No. 37 if no stiffness matrix is to be assembled.

35. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

38. Go to DMAP No. 191 and print error message if no mass matrix exists.

39. EMA assembles mass matrix $[M_{gg}]$.

41. Go to DMAP No. 44 if no weight and balance is requested.

42. GPWG generates weight and balance information.

43. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

45. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

47. Go to DMAP No. 50 if no general elements.

48. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

52. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

54. Go to DMAP No. 193 and print error message if no independent degrees of freedom are defined.

58. Go to DMAP No. 60 if no support cards.

59. Go to DMAP No. 185 and print error message if free-body supports are present.

61. Go to DMAP No. 66 if general elements present.

62. GPSP determines if possible grid point singularities remain.

64. Go to DMAP No. 66 if no grid point singularities remain.

65. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

67. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

69. Go to DMAP No. 74 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

70. MCE1 partitions multipoint constraint equations $[R_g] = [R_m | R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

72. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

75. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

77. Go to DMAP No. 80 if no single-point constraints.

78. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

81. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

83. Go to DMAP No. 86 if no omitted coordinates.

84. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}aa] + [K_{oa}^T][G_o]$.

87. RBMG2 decomposes constrained stiffness matrix $[K_{aa}] = [L_{\ell\ell}][U_{\ell\ell}]$.

89. SSG1 generates static load vectors $\{P_g\}$.

91. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

93. Go to DMAP No. 96 if no constraints applied.

94. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ -- \\ P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ -- \\ P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} + [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} P_a \\ -- \\ P_o \end{Bmatrix} \quad \text{and} \quad \{P_\ell\} = \{P_a\} + [G_o^T]\{P_o\} .$$

97. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\}$$

$$\epsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\epsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o\}}$$

100. Go to DMAP No. 103 if residual vectors are not to be printed.

101. Print residual vector for independent coordinates (RULV).

102. Print residual vector for omitted coordinates (RUØV).

104. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_\ell\} + \{u_o^o\} ,$$

$$\begin{Bmatrix} u_a \\ -- \\ u_o \end{Bmatrix} = \{u_f\} , \qquad \begin{Bmatrix} u_f \\ -- \\ Y_s \end{Bmatrix} = \{u_n\} ,$$

$$\{u_m\} = [G_m]\{u_n\} , \qquad \begin{Bmatrix} u_n \\ -- \\ u_m \end{Bmatrix} = \{u_g\} ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} .$$

106. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1), and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1) for the static solution.

108. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

110. Go to DMAP No. 114 if no static deformed structure plots are requested.

111. PLØT generates all requested static deformed structure and contour plots.

113. PRTMSG prints plotter data, engineering data, and contour data for each deformed static solution plot generated.

115. TA1 generates element tables for use in matrix assembly for differential stiffness matrix.

116. DSMG1 generates differential stiffness matrix $[K_{gg}^d]$.

119. Equivalence $[K_{gg}^d]$ to $[K_{nn}^d]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

121. Go to DMAP No. 124 if no multipoint constraints.

122. MCE2 partitions differential stiffness matrix

$$[K_{gg}^d] = \left[\begin{array}{c|c} \bar{K}_{nn}^d & K_{nm}^d \\ \hline K_{mn}^d & K_{mm}^d \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}^d] = [\bar{K}_{nn}^d] + [G_m^T][K_{mn}^d] + [K_{mn}^d][G_m] + [G_m^T][K_{mm}^d][G_m] .$$

125. Equivalence $[K^d_{nn}]$ to $[K^d_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

127. Go to DMAP No. 130 if no single-point constraints.

128. SCE1 partitions out single-point constraints

$$[K^d_{nn}] = \left[\begin{array}{c|c} K^d_{ff} & K^d_{fs} \\ \hline K^d_{sf} & K^d_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

131. Equivalence $[K^d_{ff}]$ to $[K^d_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

133. Go to DMAP No. 137 if no omitted coordinates.

134. SMP2 partitions constrained differential stiffness matrix

$$[K^d_{ff}] = \left[\begin{array}{c|c} \bar{K}^d_{aa} & K^d_{ao} \\ \hline K^d_{oa} & K^d_{oo} \end{array}\right]$$

and performs matrix reduction $[K^d_{aa}] = [\bar{K}^d_{aa}] + [K^d_{ao}][G_o]$.

135. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M^T_{oa}][G_o] + [G^T_o][M_{oa}] + [G^T_o][M_{oo}][G_o] .$$

139. Equivalence $\{P_\ell\}$ to $\{P^b_\ell\}$, $\{P_s\}$ to $\{P^b_s\}$, $\{Y_s\}$ to $\{Y^b_s\}$ and $\{u^o_o\}$ to $\{u^{ob}_o\}$ if a scale factor is not specified on a DSFACT card.

142. DSMG2 adds partitions of stiffness matrix to similar partitions of differential stiffness matrix

$$[K^b_{\ell\ell}] = [K_{aa}] + \beta[K^d_{aa}] ,$$

$$[K^b_{fs}] = [K_{fs}] + \beta[K^d_{fs}] \text{ and}$$

$$[K^b_{ss}] = [K_{ss}] + \beta[K^d_{ss}]$$

and multiplies partitions of load vectors and displacement vectors by the value of differential stiffness scale factor (β)

$$\{P_\ell^b\} = \beta\{P_\ell\} \quad , \qquad \{P_s^b\} = \beta\{P_s\} \quad ,$$

$$\{Y_s^b\} = \beta\{Y_s\} \text{ and } \qquad \{u_o^{bo}\} = \beta\{u_o^o\} \quad .$$

145. RBMG2 decomposes the combined differential stiffness matrix and elastic stiffness matrix

$$[K_{\ell\ell}^b] = [L_{\ell\ell}^b][U_{\ell\ell}^b] \quad .$$

148. PRTPARM prints the scaled value of the determinant of the combined differential stiffness matrix and elastic stiffness matrix.

149. PRTPARM prints the scale factor (power of ten) of the determinant of the combined differential stiffness matrix and the elastic stiffness matrix.

150. SSG3 solves for displacements of independent coordinates for the value of differential stiffness scale factor (β)

$$\{u_\ell^b\} = [K_{\ell\ell}^b]^{-1}\{P_\ell^b\}$$

and calculates residual vector (RBULV) and residual vector error ratio for the value of differential stiffness load factor

$$\{\delta P_\ell^b\} = \{P_\ell^b\} - [K_{\ell\ell}^b]\{u_\ell^b\} \quad ,$$

$$\epsilon_\ell^b = \frac{\{u_\ell^b\}^T\{\delta P_\ell^b\}}{\{P_\ell^b\}^T\{u_\ell^b\}}$$

153. Go to DMAP No. 155 if residual vector for the value of differential stiffness load factor is not to be printed.

154. Print residual vector for the value of differential stiffness load factor.

156. SDR1 recovers dependent displacements for the value of differential stiffness scale factor

$$\{u_o^b\} = [G_o]\{u_\ell^b\} + \{u_o^{ob}\} \quad , \qquad \begin{Bmatrix} u_\ell^b \\ \hline u_o^b \end{Bmatrix} = \{u_f^b\} \quad ,$$

$$\begin{Bmatrix} u_f^b \\ \hline Y_s^b \end{Bmatrix} = \{u_n^b\} \quad , \qquad \{u_m^b\} = [G_m]\{u_n^b\} \quad ,$$

$$\begin{Bmatrix} u_n^b \\ \hline u_m^b \end{Bmatrix} = \{u_g^b\}$$

and recovers single-point forces of constraint for the value of differential stiffness scale factor

$$\{q_s^b\} = -\{P_s^b\} + [K_{sf}^b]\{u_f^b\} + [K_{ff}^b]\{Y_s^b\} \quad .$$

158. SDR2 calculates element forces (ØEFB1) and stresses (ØESB1) and prepares displacement vectors (ØUBGV1) and single-point forces of constraint (ØQBG1) for output and the translation components of the displacement vector (PUBGV1) for the differential stiffness solution.

159. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

160. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

162. Go to DMAP No. 187 and print error message if no Eigenvalue Extraction Data.

165. READ extracts real eigenvalues from the equation

$$[K_{\ell\ell}^b - \lambda M_{aa}]\{u_a\} = 0 \quad ,$$

calculates rigid body modes by finding a square matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized, computes rigid body eigenvectors

$$[\phi_{ao}] = \frac{D\,\phi_{ro}}{\phi_{ro}}$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

168. ØFP formats eigenvalues and summary of eigenvalue extraction information prepared by READ and places them on the system output file for printing.

170. Go to DMAP No. 189 and exit if no eigenvalues found.

171. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \left\{\begin{array}{c}\phi_a \\ \hline \phi_o\end{array}\right\} = \{\phi_f\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f \\ \hline \phi_s\end{array}\right\} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n\\ \hline \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$.

174. SDR2 calculates element forces (ØBEF1) and stresses (ØBES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØBQG1) for output and the translation components of the eigenvectors (PPHIG) for the normal mode solution.

175. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

177. Go to DMAP No. 181 if no deformed real eigenvalue structure plots are requested.

178. PLØT generates all requested deformed real eigenvalue structure and contour plots.

180. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

182. Go to DMAP No. 195 and make normal exit.

184. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

186. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

188. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

190. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 4 - NØ EIGENVALUE FØUND.

192. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

194. NØRMAL MØDES WITH DIFFERENTIAL STIFFNESS ERRØR MESSAGE NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

3.14.3 Automatic Output for Normal Modes with Differential Stiffness

Each eigenvalue is identified with a mode number determined by sorting the eigenvalues by their magnitude. The following summary of the eigenvalues extracted is automatically printed:

1. Mode Number
2. Extraction Order
3. Eigenvalue
4. Radian Frequency
5. Cyclic Frequency
6. Generalized Mass
7. Generalized Stiffness

The following summary of the eigenvalue analysis performed, using the Inverse Power method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of starting points used.
3. Number of starting point moves.
4. Number of triangular decompositions.
5. Number of vector iterations.
6. Reason for termination.
   (1) Two consecutive singularities encountered while performing triangular decomposition.
   (2) Four shift points while tracking a single root.
   (3) All eigenvalues found in the frequency range specified.
   (4) Three times the number of roots estimated in the frequency range have been extracted.
   (5) All eigenvalues that exist in the problem have been found.
   (6) The number of roots desired have been found.
   (7) One or more eigenvalues have been found outside the frequency range specified.
   (8) Insufficient time to find another root.
   (9) Unable to converge.
7. Largest off-diagonal modal mass term and the number failing the criteria.

The following summary of the eigenvalue analysis performed, using the Determinant method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of passes through starting points.
3. Number of criteria changes.
4. Number of starting point moves.
5. Number of triangular decompositions.
6. Number of failures to iterate to a root.
7. Reason for termination.
   (1) The number of roots desired have been found.
   (2) All predictions for eigenvalues are outside the frequency range specified.
   (3) Insufficient time to find another root.
   (4) Matrix is singular at first three starting points.
8. Largest off-diagonal modal mass term and the number failing the criterion.
9. Swept determinant function for each starting point.

The following summary of the eigenvalue analysis performed using the Givens method, is automatically printed:

1. Number of eigenvalues extracted.
2. Number of eigenvectors computed.
3. Number of eigenvalue convergency failures.
4. Number of eigenvector convergence failures.
5. Reason for termination.
   (1) Normal termination.
   (2) Insufficient time to calculate eigenvalues and number of eigenvectors requested.
   (3) Insufficient time to find additional eigenvectors.
6. Largest off-diagonal modal mass term and the number failing the criterion.

The value of the determinant of the sum of the elastic stiffness and the differential stiffness is automatically printed.

3.14.4 Case Control Deck and Parameters for Normal Modes with Differential Stiffness

The following items relate to subcase definition and data selection for Normal Modes with Differential Stiffness:

1. The Case Control Deck must contain three subcases. Output selections may be made above the subcase level and within the individual subcases.

2. The linear solution is output from the first subcase. The static differential stiffness solution is output from the second subcase. The eigenvector solution is output from the third subcase.

3. An SPC set must be selected above the subcase level unless all constraints are specified on GRID cards.

4. A static loading condition must be defined in the first subcase with a LØAD, TEMPERATURE (LØAD), or DEFØRM selection, unless all loading is specified by grid point displacements on SPC cards.

5. DSCØEFFICIENT must appear in the second subcase, either to select a DSFACT set from the Bulk Data Deck, or to explicitly select the DEFAULT value of unity.

6. METHØD must appear in the third subcase to select an EIGR bulk data card.

The following output may be requested for Normal Modes with Differential Stiffness:

1. Nonzero components of the applied static load for the linear solution at selected grid points.

2. Displacement and nonzero components of the single-point forces of constraint, with and without differential stiffness, at selected grid points.

3. Forces and stresses in selected elements, with and without differential stiffness.

4. Deformed and undeformed plots with and without differential stiffness.

5. Contour plots of stress and displacement with and without differential stiffness.

The following output may be requested for the Normal Mode Analysis subcase.

1. Eigenvectors along with the associated eigenvalue for each mode.

2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.

3. Forces and stresses in selected elements for selected modes.

4. Undeformed plot of the structural model and mode shapes for selected modes.

5. Contour plots of stress and displacement for selected modes.

The following parameters are used in Normal Mode Analysis:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of couples mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

3.14.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.15 STATIC ANALYSIS USING CYCLIC SYMMETRY

3.15.1 DMAP Sequence for Static Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES D

DISPLACEMENT APPROACH, RIGID FORMAT 14

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    NO.14 STATIC ANALYSIS WITH CYCLIC SYMMETRY - SERIES D $

    2  FILE     KKK=SAVE/PK=SAVE $

    3  FILE     UXV=APPEND $

    4  PARAM    //C,N,NOP/V,Y,CYCIO=1 $

    5  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    6  SAVE     LUSET $

    7  CHKPNT   GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

    8  GP2      GEOM2,EQEXIN/ECT $

    9  CHKPNT   ECT $

   10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   12  COND     P1,NOPCDB $

   13  PLTSET   PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/   V,N,
                JUMPPLOT=-1 $

   14  SAVE     NSIL,JUMPPLOT $

   15  PRTMSG   PLTSETX// $

   16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   18  COND     P1,JUMPPLOT $


   19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

   20  SAVE     JUMPPLOT,PLTFLG,PFILE $

   21  PRTMSG   PLOTX1// $

   22  LABEL    P1 $

   23  CHKPNT   PLTPAR,GPSETS,ELSETS $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  GP3      GEOM3,EQEXIN,GEOM2/SLT,GPTT/V,N,NOGRAV $

25  SAVE     NOGRAV $

26  PARAM    //C,N,AND/V,N,NOMGG/V,N,NOGRAV/V,Y,GRDPNT=-1 $

27  CHKPNT   SLT,GPTT $

28  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

29  SAVE     NOSIMP,NOGENL,GENEL $

30  PARAM    //C,N,AND/V,N,NOELMT/V,N,NOGENL/V,N,NOSIMP $

31  COND     ERROR4,NOELMT $

32  PURGE    GPST/NOSIMP/OGPST/GENEL $

33  CHKPNT   EST,GPECT,GEI,GPST,OGPST $

34  COND     LBL1,NOSIMP $

35  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

36  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
             N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/C,Y,
             CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/  C,Y,CPTUBE/C,Y,
             CPQDPLT/C,Y,CPTPPLT/C,Y,CPTRBSC $

37  SAVE     NOKGGX,NOMGG $

38  CHKPNT   KELM,KDICT,MELM,MDICT $

39  COND     JMPKGG,NOKGGX $

40  EMA      GPECT,KDICT,KELM/KGGX,GPST $

41  CHKPNT   KGGX,GPST $


42  LABEL    JMPKGG $

43  COND     JMPMGG,NOMGG $

44  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

45  CHKPNT   MGG $

46  LABEL    JMPMGG $

47  COND     LBL1,GRDPNT $
```

STATIC ANALYSIS USING CYCLIC SYMMETRY

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  COND      ERROR2,NOMGG $

49  GPWG      BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT/C,Y,WTMASS $

50  OFP       OGPWG,,,,,// $

51  LABEL     LBL1 $

52  EQUIV     KGGX,KGG/NOGENL $

53  CHKPNT    KGG $

54  COND      LBL11A,NOGENL $

55  SMA3      GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $

56  CHKPNT    KGG $

57  LABEL     LBL11A $

58  PARAM     //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

59  GP4       CASECC,GEOM4,EQEXIN,CPDT,BGPDT,CSTM/RG,YS,USET,ASET/V,N,LUSET/
              V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
              N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

60  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

61  COND      ERROR3,NOL $

62  PARAM     //C,N,NOT/V,N,REACDATA/V,N,REACT $

63  COND      ERROR6,REACDATA $

64  PURGE     GM/MPCF1/GO,KOO,LOO,PO,UOOV,RUOV/OMIT/PS,KFS,KSS,QG/SINGLE $

65  CHKPNT    GM,GO,KOO,LOO,PO,UOOV,RUOV,PS,KFS,KSS,QG,USET,RG,YS,ASET $

66  GPCYC     GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $

67  SAVE      NOGO $

68  CHKPNT    CYCD $

69  COND      ERROR7,NOGO $

70  COND      LBL4,GENEL $

71  GPSP      GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

72  SAVE      NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  COND      LBL4,NOGPST $
74  OFP       OGPST,,,,,// $
75  LABEL     LBL4 $
76  EQUIV     KGG,KNN/MPCF1 $
77  CHKPNT    KNN $
78  COND      LBL2,MPCF2 $
79  MCE1      USET,RG/GM $
80  CHKPNT    GM $
81  MCE2      USET,GM,KGG,,,/KNN,,, $
82  CHKPNT    KNN $
83  LABEL     LBL2 $
84  EQUIV     KNN,KFF/SINGLE $
85  CHKPNT    KFF $
86  COND      LBL3,SINGLE $
87  SCE1      USET,KNN,,,/KFF,KFS,KSS,,, $
88  CHKPNT    KFS,KSS,KFF $
89  LABEL     LBL3 $
90  EQUIV     KFF,KAA/OMIT $
91  CHKPNT    KAA $
92  COND      LBL5,OMIT $

93  SMP1      USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $
94  CHKPNT    GO,KAA,KOO,LOO $
95  LABEL     LBL5 $
96  SSG1      SLT,BGPDT,CSTM,SIL,EST,MPT,GPTT,EDT,MGG,CASECC,DIT/PG/V,N,
              LUSET/V,N,NSKIP $
97  CHKPNT    PG $
98  EQUIV     PG,PL/NOSET $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  CHKPNT   PL $
100  COND     LBL9,NOSET $
101  SSG2     USET,GM,YS,KFS,GO,,PG/,PO,PS,PL $
102  CHKPNT   PO,PS,PL $
103  COND     LBL9,OMIT $
104  SSG3     LOO,KOO,PO,,,/UOOV,,RUOV,/C,N,-1/V,Y,IRES=-1 $
105  CHKPNT   UOOV,RUOV $
106  COND     LBL9,IRES $
107  MATGPR   GPL,USET,SIL,RUOV//C,N,0 $
108  LABEL    LBL9 $
109  EQUIV    PL,PX/CYCIO $
110  COND     LBL10,CYCIO $
111  CYCT1    PL/PX,GCYCF/V,Y,CTYPE/C,N,FORE/V,Y,NSEGS=-1/V,Y,KMAX=-1/V,Y,
              NLOAD=1/V,N,NOGO $
112  SAVE     KMAX,NOGO $
113  LABEL    LBL10 $
114  CHKPNT   PX $
115  COND     ERROR7,NOGO $
116  PARAM    //C,N,ADD/V,N,KINDEX/C,N,0/C,N,0 $
117  JUMP     LBL11 $
---------------------------------------------------- Top of DMAP Loop
118  LABEL    LBL11 $

119  CYCT2    CYCD,KAA,,PX,,/KKK,,PK,,/C,N,FORE/V,Y,NSEGS/V,N,KINDEX/V,Y,
              CYCSEQ=-1/V,Y,NLOAD/V,N,NOGO $
120  SAVE     NOGO $
121  CHKPNT   KKK,PK $
122  COND     ERROR7,NOGO $
123  RBMG2    KKK/LKK $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
124  CHKPNT   LKK $
125  SSG3     LKK,KKK,PK,,,/UKV,,RUKV,/C,N,-1/V,Y,IRES $
126  CHKPNT   UKV,RUKV $
127  CYCT2    CYCD,,,UKV,RUKV,/,,UXV,RUXV,/C,N,BACK/V,Y,NSEGS/V,N,KINDEX/
              V,Y,CYCSEQ/V,Y,NLOAD/V,N,NOGO $
128  SAVE     NOGO $
129  CHKPNT   UXV,RUXV $
130  COND     ERROR7,NOGO $
131  COND     LBL14,IRES $
132  MATGPR   GPL,USET,SIL,RUXV//C,N,A $
133  LABEL    LBL14 $
134  PARAM    //C,N,ADD/V,N,KINDEX/V,N,KINDEX/C,N,1 $
135  PARAM    //C,N,SUB/V,N,DONE/V,Y,KMAX/V,N,KINDEX $
136  COND     LBL15,DONE $
137  REPT     LBL11,360 $
------------------------------------------------------ Bottom of DMAP Loop
138  JUMP     ERROR1 $
139  LABEL    LBL15 $
140  EQUIV    UXV,ULV/CYCIO $
141  COND     LBL16,CYCIO $
142  CYCT1    UXV/ULV,GCYCB/V,Y,CTYPE/C,N,BACK/V,Y,NSEGS/V,Y,KMAX/V,Y,NLOAD/
              V,N,NOGO $
143  SAVE     NOGO $
144  COND     ERROR7,NOGO $
145  LABEL    LBL16 $
146  CHKPNT   ULV $
147  SDR1     USET,PG,ULV,UOOV,YS,GO,GM,PS,KFS,KSS,/UGV,PGG,QG/V,N,NSKIP/C,N,
              STATICS $
148  CHKPNT   UGV,PGG,QG $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 14

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
149  SDR2     CASECC,CSTM,MPT,DIT,EQEXIN,SIL,GPTT,EDT,BGPDT,,QG,UGV,EST,,PGG/
              OPG1,OQG1,OUGV1,OES1,OEF1,PUGV1/C,N,STATICS $
150  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
151  OFP      OUGV1,OPG1,OQG1,OEF1,OES1,//V,N,CARDNO $
152  SAVE     CARDNO $
153  COND     P2,JUMPPLOT $
154  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,PUGV1,,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
155  SAVE     PFILE $
156  PRTMSG   PLOTX2// $
157  LABEL    P2 $
158  JUMP     FINIS $
159  LABEL    ERROR1 $
160  PRTPARM  //C,N,-1/C,N,CYCSTATICS $
161  LABEL    ERROR2 $
162  PRTPARM  //C,N,-2/C,N,CYCSTATICS $
163  LABEL    ERROR3 $
164  PRTPARM  //C,N,-3/C,N,CYCSTATICS $
165  LABEL    ERROR4 $
166  PRTPARM  //C,N,-4/C,N,CYCSTATICS $
167  LABEL    ERROR6 $

168  PRTPARM  //C,N,-6/C,N,CYCSTATICS $
169  LABEL    ERROR7 $
170  PRTPARM  //C,N,-7/C,N,CYCSTATICS $
171  LABEL    FINIS $
172  END      $
```

3.15.2 Description of DMAP Operations for Static Analysis Using Cyclic Symmetry

5. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

8. GP2 generates Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive structure plotter.

15. PRTMSG prints error messages associated with structure plotter.

18. Go to DMAP No. 22 if no undeformed structure plots are requested.

19. PLØT generates all requested undeformed structure plots.

21. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

24. GP3 generates Static Loads Table and Grid Point Temperature Table.

28. TA1 generates element tables for use in matrix assembly and stress recovery.

31. Go to DMAP No. 165 and print error message if no elements have been defined.

34. Go to DMAP No. 51 if there are no structural elements.

36. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

39. Go to DMAP No. 42 if no stiffness matrix is to be assembled.

40. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

43. Go to DMAP No. 46 if no mass matrix is to be assembled.

44. EMA assembles mass matrix $[M_{gg}]$.

47. Go to DMAP No. 51 if no weight and balance is requested.

48. Go to DMAP No. 161 and print error message if no mass matrix exists.

49. GPWG generates weight and balance information.

50. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

52. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

54. Go to DMAP No. 57 if no general elements.

55. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

59. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

61. Go to DMAP No. 163 and print error message if no independent degrees of freedom are defined.

63. Go to DMAP No. 167 and print error message if free-body supports are present.

66. GPCYC prepares segment boundary table.

69. Go to DMAP No. 169 and print error message if CYJØIN data is inconsistent.

70. Go to DMAP No. 75 if general elements present.

71. GPSP determines if possible grid point singularities remain.

73. Go to DMAP No. 75 if no grid point singularities remain.

74. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

76. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

78. Go to DMAP No. 83 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

79. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

81. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

84. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

86. Go to DMAP No. 89 if no single-point constraints.

87. SCE1 partitions out single-point constraints.

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right]$$

90. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

92. Go to DMAP No. 95 if no omitted coordinates.

93. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

96. SSG1 generates static load vectors $\{P_g\}$.

98. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

101. SSG2 applies constraints to static load vectors

$$\{P_g\} = \begin{Bmatrix} \bar{P}_n \\ -- \\ P_m \end{Bmatrix} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \begin{Bmatrix} \bar{P}_f \\ -- \\ P_s \end{Bmatrix} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \begin{Bmatrix} \bar{P}_a \\ -- \\ P_o \end{Bmatrix} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \begin{Bmatrix} P_\ell \\ -- \\ P_r \end{Bmatrix}$$

and calculates determinate forces of reaction $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

103. Go to DMAP No. 108 if no omitted coordinates.

104. SSG3 solves for displacements of omitted coordinates (these are not transformed)

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} ,$$

$$\epsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} .$$

106. Go to DMAP No. 108 if residual vectors are not to be printed.

107. MATGPR prints the residual vector for omitted coordinates (RUØV).

109. Equivalence $\{P_\ell\}$ to $\{P_x\}$ if symmetric components of loads have been input.

110. Go to DMAP No. 113 if symmetric components of loads have been input.

111. CYCT1 transforms loads on analysis points to symmetric components by the equation

$$\{P_x\} = [G]\{P_\ell\} \quad .$$

115. Go to DMAP No. 169 and print error message if CYCT1 error was found.

117. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

118. Beginning of loop for cyclic index values (KINDEX).

119. CYCT2 transforms matrices and loads from symmetric components to solution set by the equations

$$[K_{kk}] = [G_1^T][K_{aa}][G_1] + [G_2^T][K_{aa}[G_2],$$

where $G_1 = G_c$ (cosine) and $G_2 = G_s$ (sine) for rotational symmetry,

and $G_1 = G_S$ (Symmetric) and $G_2 = G_A$ (Antisymmetric) for dihedral symmetry.

$$\{P_k\} = [G_c^T]\{P_c\} + [G_s^T]\{P_s\} \text{ for rotational symmetry.}$$

$$\{P_k^1\} = [G_S^T]\{P_{cS}\} + [G_A^T]\{P_{sA}\},$$

and $\{P_k^2\} = [G_A^T]\{P_{cA}\} + [G_S^T]\{P_{sS}\}$ for dihedral symmetry.

122. Go to DMAP No. 169 and print error message if CYCT2 error was found.

123. RBMG2 decomposes constrained stiffness matrix for solution set.

$$[K_{kk}] = [L_{kk}][u_{kk}]$$

125. SSG3 solves for displacements of solution set coordinates

$$\{u_k\} = [K_{kk}]^{-1}\{P_k\} \quad ,$$

and calculates residual vector (RUKV) and residual vector error ratio for solution set coordinates

$$\{\delta P_k\} = \{P_k\} - [K_{kk}]\{u_k\} \quad ,$$

$$\epsilon_k = \frac{\{u_k^T\}\{\delta P_k\}}{\{P_k^T\}\{u_k\}}$$

127. CYCT2 finds symmetric components of displacement from solution set data and appends to output for each KINDEX.

130. Go to DMAP No. 169 and print error message if CYCT2 error was found.

131. Go to DMAP No. 133 if residual vectors are not to be printed.

132. MATGPR prints the residual vector for solution set coordinates (RUXV).

136. Go to DMAP No. 139 if all cyclic index (KINDEX) values are complete.

137. Go to DMAP No. 118 if additional index values are needed.

138. Go to DMAP No. 159 and print error message if number of loops exceeds 360.

140. Equivalence $\{u_x\}$ to $\{u_\ell\}$ if output of symmetric components was requested.

141. Go to DMAP No. 145 if output of symmetric components was requested.

142. CYCT1 transforms displacements from symmetrical components to physical components.

144. Go to DMAP No. 169 and print error message if CYCT1 error was found.

147. SDR1 recovers dependent displacements

$$\{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ -- \\ u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ -- \\ Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ -- \\ u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point forces of constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

149. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares load vectors (ØPG1), displacement vectors (ØUGV1) and single-point forces of constraint (ØQG1) for output and translation components of the displacement vector (PUGV1).

151. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

152. Go to DMAP No. 157 if no deformed structure plots are requested.

154. PLØT generates all requested deformed structure and contour plots.

156. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

158. Go to DMAP No. 171 and make normal exit.

160. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

162. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

164. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDOM HAVE BEEN DEFINED.

166. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

168. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - FREE-BØDY SUPPØRTS NØT ALLØWED.

170. STATICS WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 7 - CYCLIC SYMMETRY DATA ERRØR.

3.15.3 Case Control Deck and Parameters for Static Analysis Using Cyclic Symmetry

The following items relate to subcase definition and data selection:

1. A separate group of subcases must be defined for each symmetric segment. For dihedral symmetry, a separate group of subcases are defined for each half. There may be up to 360 subcases corresponding to 1° segments.

2. The different loading conditions are defined within each group of subcases. The loads on each symmetric segment and the selected output requests may be independent. The number of loading cases is specified on the PARAM card NLØAD.

3. The SPC and MPC request must appear above the subcase level and may not be changed.

4. An alternate loading method is to define a separate group of subcases for each harmonic index, k. The parameter CYCIØ is included and the load components for each index are defined directly within each group for the various loading conditions.

The following printed output, for each loading condition and each symmetric segment or index, may be requested for Static Analysis solutions:

1. Displacements and components of static loads and single-point forces of constraint at selected grid points or scalar points.

2. Forces and stresses in selected elements.

The following plotter output may be requested for Static Analysis solutions:

1. Undeformed and deformed plots of the structural model (1 segment).

2. Contour plots of stress and displacement (1 segment).

3. X-Y plot of any component of displacement, static load, or single-point force of constraint for a grid point or scalar point.

4. X-Y plot of any stress or force component for an element.

The following parameters are used in Static Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed.

2. WTMASS - optional - the terms of the mass matrix are multiplied by the real value of this parameter when they are generated in EMA.

C-7

3.16 NORMAL MODES ANALYSIS USING CYCLIC SYMMETRY

3.16.1 DMAP Sequence for Normal Modes Analysis Using Cyclic Symmetry

```
RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 15

   LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO     ERR=2  NOLIST  NODECK  NOREF  NOOSCAR

   1  BEGIN     NO.15 NORMAL MODES ANALYSIS WITH CYCLIC SYMMETRY SERIES 0 $

   2  GP1       GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

   3  SAVE      LUSET $

   4  CHKPNT    GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL $

   5  GP2       GEOM2,EQEXIN/ECT $

   6  CHKPNT    ECT $

   7  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   8  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   9  COND      P1,NOPCDB $

  10  PLTSET    PCDB,EQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
                JUMPPLOT=-1 $

  11  SAVE      NSIL,JUMPPLOT $

  12  PRTMSG    PLTSETX// $

  13  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  14  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  15  COND      P1,JUMPPLOT $

  16  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIL,,ECT,,/PLOTX1/V,N,
                NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  17  SAVE      JUMPPLOT,PLTFLG,PFILE $

  18  PRTMSG    PLOTX1//$


  19  LABEL     P1 $

  20  CHKPNT    PLTPAR,GPSETS,ELSETS $

  21  GP3       GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

  22  CHKPNT    GPTT $

  23  TA1       ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/  V,N,
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 15

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
                  NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

24   SAVE         NOGENL,NOSIMP,GENEL $

25   COND         ERROR6,NOSIMP $

26   PURGE        OGPST/GENEL $

27   CHKPNT       EST,GPECT,GEI,OGPST $

28   PARAM        //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

29   PARAM        //C,N,ADD/V,N,NOMGG/C,N,1/C,N,0 $

30   EMG          EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                  N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
                  CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
                  CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

31   SAVE         NOKGGX,NOMGG $

32   CHKPNT       KELM,KDICT,MELM,MDICT $

33   COND         JMPKGG,NOKGGX $

34   EMA          GPECT,KDICT,KELM/KGGX,GPST $

35   CHKPNT       KGGX,GPST $

36   LABEL        JMPKGG $

37   COND         ERROR1,NOMGG $

38   EMA          GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

39   CHKPNT       MGG $

40   COND         LGPWG,GRDPNT $

41   GPWG         BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $


42   OFP          OGPWG,,,,,// $

43   LABEL        LGPWG $

44   EQUIV        KGGX,KGG/NOGENL $

45   CHKPNT       KGG $

46   COND         LBL11,NOGENL $

47   SMA3         GEI,KGGX/KGG/V,N,LUSET/V,N,NOGENL/V,N,NOSIMP $
```

RIGID FORMAT DMAP LISTING
SERIES O

DISPLACEMENT APPROACH, RIGID FORMAT 15

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  CHKPNT   KGG $

49  LABEL    LBL11 $

50  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

51  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/  V,N,LUSET/
             V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/V,N,NSKIP/V,
             N,REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

52  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,REPEAT,NOSET,NOL,NOA $

53  COND     ERROR3,NOL $

54  PARAM    //C,N,NOT/V,N,REACDATA/V,N,REACT $

55  COND     ERROR4,REACDATA $

56  PURGE    GM/MPCF1/GO/OMIT/KFS,QG/SINGLE $

57  CHKPNT   GM,RG,GO,KFS,QG,USET,ASET $

58  GPCYC    GEOM4,EQEXIN,USET/CYCD/V,Y,CTYPE/V,N,NOGO $

59  SAVE     NOGO $

60  CHKPNT   CYCD $

61  COND     ERROR5,NOGO $

62  COND     LBL4,GENEL $

63  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

64  SAVE     NOGPST $

65  COND     LBL4,NOGPST $

66  OFP      OGPST,,,,,,// $


67  LABEL    LBL4 $

68  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

69  CHKPNT   KNN,MNN $

70  COND     LBL2,MPCF2 $

71  MCE1     USET,RG/GM $

72  CHKPNT   GM $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 15

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $

74  CHKPNT   KNN,MNN $

75  LABEL    LBL2 $

76  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

77  CHKPNT   KFF,MFF $

78  COND     LBL3,SINGLE $

79  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $

80  CHKPNT   KFS,KFF,MFF $

81  LABEL    LBL3 $

82  EQUIV    KFF,KAA/OMIT $

83  EQUIV    MFF,MAA/OMIT $

84  CHKPNT   KAA,MAA $

85  COND     LBL5,OMIT $

86  SMP1     USET,KFF,,,/GO,KAA,KOO,LOO,,,,, $

87  CHKPNT   GO,KAA $

88  SMP2     USET,GO,MFF/MAA $

89  CHKPNT   MAA $

90  LABEL    LBL5 $

91  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,,,,,,,EED,EQDYN/V,N,
             LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/  V,
             N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,/V,N,NOUE $


92  SAVE     NOEED $

93  COND     ERROR2,NOEED $

94  CHKPNT   EED $

95  CYCT2    CYCD,KAA,MAA,,,/KKK,MKK,,,/C,N,FORE/V,Y,NSEGS=-1/V,Y,KINDEX=-1/
             V,Y,CYCSEQ=-1/C,N,1/V,N,NOGO $

96  SAVE     NOGO $

97  CHKPNT   KKK,MKK $
```

RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 15

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  COND      ERROR5,NOGO $

 99  READ      KKK,MKK,,,EED,,CASECC/LAMK,PHIK,MI,OEIGS/C,N,MODES/V,N,NEIGV $

100  SAVE      NEIGV $

101  CHKPNT    LAMK,PHIK,MI,OEIGS $

102  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

103  OFP       LAMK,OEIGS,,,,//V,N,CARDNO $

104  SAVE      CARDNO $

105  COND      FINIS,NEIGV $

106  CYCT2     CYCD,,,,PHIK,LAMK/,,,PHIA,LAMA/C,N,BACK/V,Y,NSEGS/V,Y,KINDEX/
               V,Y,CYCSEQ/C,N,1/V,N,NOGO $

107  SAVE      NOGO $

108  CHKPNT    PHIA,LAMA $

109  COND      ERROR5,NOGO $

110  SDR1      USET,,PHIA,,,GO,GM,,KFS,,/PHIG,,QG/C,N,1/C,N,REIG $

111  CHKPNT    PHIG,QG $

112  PARAM     //C,N,SUB/V,N,SCALAR/V,N,SIL/V,N,LUSET $

113  EQUIV     SIL,SIP/SCALAR/BGPDT,BGPDP/SCALAR $

114  CHKPNT    SIP,BGPDP $

115  COND      LBL7,SCALAR $

116  PLTTRAN   BGPDT,SIL/BGPDP,SIP/V,N,LUSET/V,N,LUSEP $

117  SAVE      LUSEP $


118  CHKPNT    BGPDP,SIP $

119  LABEL     LBL7 $

120  SDR2      CASECC,CSTM,MPT,DIT,EQEXIN,SIL,,,BGPDP,LAMA,QG,PHIG,EST,,/,
               OQG1,OPHIG,OES1,OEF1,PPHIG/C,N,REIG $

121  OFP       OPHIG,OQG1,OEF1,OES1,,//V,N,CARDNO $

122  SAVE      CARDNO $
```

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RIGID FORMAT DMAP LISTING
SERIES 0

DISPLACEMENT APPROACH, RIGID FORMAT 15

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  COND     P2,JUMPPLOT $

124  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,EQEXIN,SIP,,PPHIG,GPECT,OES1/
              PLOTX2/V,N,NSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

125  SAVE     PFILE $

126  PRTMSG   PLOTX2// $

127  LABEL    P2 $

128  JUMP     FINIS $

129  LABEL    ERROR1 $

130  PRTPARM  //C,N,-1/C,N,CYCMODES $

131  LABEL    ERROR2 $

132  PRTPARM  //C,N,-2/C,N,CYCMODES $

133  LABEL    ERROR3 $

134  PRTPARM  //C,N,-3/C,N,CYCMODES $

135  LABEL    ERROR4 $

136  PRTPARM  //C,N,-4/C,N,CYCMODES $

137  LABEL    ERROR5 $

138  PRTPARM  //C,N,-5/C,N,CYCMODES $

139  LABEL    ERROR6 $

140  PRTPARM  //C,N,-6/C,N,CYCMODES $

141  LABEL    FINIS $

142  END      $
```

3.16.2 Description of DMAP Operations for Normal Modes Analysis Using Cyclic Symmetry

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. GP2 generates Element Connection Table with internal indices.

9. Go to DMAP No. 19 if no plot output is requested.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed structure plots are requested.

16. PLØT generates all requested undeformed structure plots.

18. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

21. GP3 generates Static Loads Table and Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly and stress recovery.

25. Go to DMAP No. 139 and print error message if no elements have been defined.

30. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

33. Go to DMAP No. 36 if no stiffness matrix is to be assembled.

34. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

37. Go to DMAP No. 129 and print error message if no mass matrix exists.

38. EMA assembles mass matrix $[M_{gg}]$.

40. Go to DMAP No. 43 if no weight and balance request.

41. GPWG generates weight and balance information.

42. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

44. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

46. Go to DMAP No. 49 if no general elements.

47. SMA3 adds general elements to $[K^x_{gg}]$ to obtain stiffness matrix $[K_{gg}]$.

51. GP4 generates flags defining members of various displacement sets (USET), forms multi-point constraint equations $[R_g]\{u_g\} = 0$ and forms enforced displacement vector $\{Y_s\}$.

53. Go to DMAP No. 133 and print error message if no independent degrees of freedom are defined.

55. Go to DMAP No. 135 and print error message if free-body supports are present.

58. GPCYC prepares segment boundary table.

61. Go to DMAP No. 137 and print error message if CYJØIN data is inconsistent.

62. Go to DMAP No. 67 if general elements present.

63. GPSP determines if possible grid point singularities remain.

65. Go to DMAP No. 67 if no grid point singularities remain.

66. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

68. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

70. Go to DMAP No. 75 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

71. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

73. MCE2 partitions stiffness matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] .$$

76. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

78. Go to DMAP No. 81 if no single-point constraints.

79. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \qquad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

82. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

83. Equivalence $[M_{ff}]$ to $[M_{aa}]$ if no omitted coordinates.

85. Go to DMAP No. 90 if no omitted coordinates.

86. SMP1 partitions constrained stiffness matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

solves for transformation matrix $[G_c] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

88. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oa}] + [G_o^T][M_{oo}][G_o] .$$

91. DPD extracts Eigenvalue Extraction Data from Dynamics data block.

93. Go to DMAP No. 131 and print error message if no Eigenvalue Extraction Data.

95. CYCT2 transforms matrices from symmetric components to solution set by the equations

$$[K_{kk}] = [G_1^T][K_{aa}][G_1] + [G_2^T][K_{aa}][G_2],$$

and $$[M_{kk}] = [G_1^T][M_{aa}][G_1] + [G_2^T][M_{aa}][G_2],$$

where $G_1 = G_c$ (cosine) and $G_2 = G_s$ (sine) for rotational symmetry,

and $G_1 = G_S$ (Symmetric) and $G_2 = G_A$ (Antisymmetric) for dihedral symmetry.

98. Go to DMAP No. 137 and print error message if CYCT2 error was found.

99. READ extracts real eigenvalues from the equation

$$[K_{kk} - \lambda M_{kk}]\{u_k\} = 0 \quad ,$$

calculates modal mass matrix

$$[m] = [\phi_k^T][M_{kk}][\phi_k]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass.

103. ØFP formats eigenvalues (LAMK) and summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

105. Go to DMAP No. 141 and exit if no eigenvalues found.

106. CYCT2 finds symmetric components of eigenvectors from solution set eigenvectors.

109. Go to DMAP No. 137 and print error message if CYCT2 error was found.

110. SDR1 recovers dependent components of the eigenvectors

$$\{\phi_o\} = [G_o]\{\phi_a\} \quad , \qquad \left\{\begin{array}{c}\phi_a \\ -- \\ \phi_o\end{array}\right\} = \{\phi_f\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f \\ -- \\ \phi_s\end{array}\right\} = \{\phi_n\} \quad , \qquad \{\phi_m\} = [G_m]\{\phi_n\} \quad ,$$

$$\left\{\begin{array}{c}\phi_n \\ -- \\ \phi_m\end{array}\right\} = \{\phi_g\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}]^T\{\phi_f\}$.

113. Equivalence SIL to SIP and BGPDT to BGPDP when one or more geometric grid points exist.

116. PLTTRAN modifies BGPDT and SIL for functional modules SDR2 and PLØT.

120. SDR2 calculates element forces (ØEF1) and stresses (ØES1) and prepares eigenvectors (ØPHIG) and single-point forces of constraint (ØQG1) for output and translation components of the eigenvectors (PPHIG).

121. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

123. Go to DMAP No. 127 if no deformed structure plots are requested.

124. PLØT generates all requested deformed structure and contour plots.

126. PRTMSG prints plotter data, engineering data, and contour data for each deformed plot generated.

128. Go to DMAP No. 141 and make normal exit.

130. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

132. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

134. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

136. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 4 - FREE BØDY SUPPØRTS NØT ALLØWED.

138. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 5 - CYCLIC SYMMETRY DATA ERRØR.

140. NØRMAL MØDES WITH CYCLIC SYMMETRY ERRØR MESSAGE NØ. 6 - NØ STRUCTURAL ELEMENTS DEFINED.

3. Multiple subcases are used only to control output requests. A single subcase is sufficient if the same output is desired for all modes. If multiple subcases are present, the output requests will be honored in succession for increasing mode numbers. MØDES may be used to repeat subcases in order to make the same output request for several consecutive modes.

Each NASTRAN run calculates modes for only one symmetry index, k. The following output may be requested for Normal Mode Analysis with Cyclic Symmetry:

1. Eigenvectors along with the associated eigenvalue for each mode.
2. Nonzero components of the single-point forces of constraint for selected modes at selected grid points.
3. Forces and stresses in selected elements for selected modes.
4. Undeformed plot of the structural model and mode shapes for selected modes.
5. Contour plots of stress and displacement for selected modes.

The following parameters are used in Normal Mode Analysis using Cyclic Symmetry:

1. GRDPNT - optional - a positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.
2. WTMASS - optional - the terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.
3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - these parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.
4. CTYPE - required - the BCD value of this parameter defines the type of cyclic symmetry as follows:

   (1) RØT - rotational symmetry

   (2) DRL - dihedral symmetry, using right and left halves

   (3) DSA - dihedral symmetry, using symmetric and antisymmetric components

5. NSEGS - required - the integer value of this parameter is the number of identical segments in the structural model.

6. CYCSEQ - optional - the integer value of this parameter specifies the procedure for sequencing the equations in the solution set. A value of +1 specifies that all cosine terms should be sequenced before all sine terms, and a value of -1 for alternating the cosine and sine terms. The default value is -1.

7. KINDEX - required in normal modes with cyclic symmetry (Rigid Format 15). The integer value of this parameter specifies a single value of the harmonic index.

3.16.5 Optional Diagnostic Output for FEER

Special detailed information resulting from requesting DIAG 16 in the Executive Control Deck is the same as described under Normal Modes analysis (see Section 3.4.6).

3.17 STATIC HEAT TRANSFER ANALYSIS

3.17.1 <u>DMAP Sequence for Static Heat Transfer Analysis</u>

```
RIGID FORMAT DMAP LISTING
SERIES 0

HEAT APPROACH, RIGID FORMAT 1

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN     NO.01 STATIC HEAT TRANSFER ANALYSIS - SERIES 0 $

    2  FILE      HLLL=TAPE $

    3  FILE      HQG=APPEND/HPGG=APPEND/HUGV=APPEND/HGM=SAVE/HKNN=SAVE $

    4  GP1       GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/   V,
                 N,NOGPDT $

    5  SAVE      HLUSET $

    6  CHKPNT    GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $

    7  GP2       GEOM2,HEQEXIN/ECT $

    8  CHKPNT    ECT $

    9  PARAML    PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   10  PURGE     PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   11  COND      HP1,NOPCDB $

   12  PLTSET    PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
                 JUMPPLOT=-1 $

   13  SAVE      HNSIL,JUMPPLOT $

   14  PRTMSG    PLTSETX// $

   15  PARAM     //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

   16  PARAM     //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

   17  COND      HP1,JUMPPLOT $

   18  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
                 V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $


   19  SAVE      JUMPPLOT,PLTFLG,PFILE $

   20  PRTMSG    PLOTX1// $

   21  LABEL     HP1 $

   22  CHKPNT    PLTPAR,GPSETS,ELSETS $

   23  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $
```

RIGID FORMAT DMAP LISTING
SERIES 0

HEAT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
24  CHKPNT   HSLT,GPTT $

25  TA1      ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
             NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

26  SAVE     NOSIMP $

27  COND     ERROR4,NOSIMP $

28  PURGE    GPST/NOSIMP $

29  CHKPNT   HEST,HGPECT,GPST $

30  COND     HLBL1,NOSIMP $

31  PARAM    //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $

32  EMG      HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $

33  SAVE     HNOKGG $

34  CHKPNT   HKELM,HKDICT $

35  COND     HLBL1,HNOKGG $

36  EMA      HGPECT,HKDICT,HKELM/HKGG,GPST $

37  CHKPNT   HKGG,GPST $

38  LABEL    HLBL1 $

39  PARAM    //C,N,MPY/V,N,NSKIP/C,N,0/C,N,0 $

40  JUMP     HLBL11 $
------------------------------------------------------ Top of DMAP Loop
41  LABEL    HLBL11 $

42  GP4      CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/ V,N,
             HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/   V,
             N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

43  SAVE     MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $

44  COND     ERROR3,NOL $

45  PARAM    //C,N,AND/V,N,NOSR/V,N,SINGLE/V,N,REACT $

46  PURGE    HKRR,HKLR,HQR,HDM/REACT/GM/MPCF1/HGO,HKOO,HLOO,HPO,HUOOV,
             HRUOV/OMIT/HPS,HKFS,HKSS/SINGLE/HQG/NOSR $

47  CHKPNT   HKRR,HKLR,HQR,HDM,GM,HGO,HKOO,HLOO,HPO,HUOOV,HRUOV,HPS,HKFS,
             HKSS,HQG,HUSET,RG,YS,HASET $
```

RIGID FORMAT DMAP LISTING
SERIES 0

HEAT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  GPSP     GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $
49  SAVE     NOGPST $
50  COND     HLBL4,NOGPST $
51  OFP      OGPST,,,,,// $
52  LABEL    HLBL4 $
53  EQUIV    HKGG,HKNN/MPCF1 $
54  CHKPNT   HKNN $
55  COND     HLBL2,MPCF2 $
56  MCE1     HUSET,RG/GM $
57  CHKPNT   GM $
58  MCE2     HUSET,GM,HKGG,,,/HKNN,,, $
59  CHKPNT   HKNN $
60  LABEL    HLBL2 $
61  EQUIV    HKNN,HKFF/SINGLE $
62  CHKPNT   HKFF $
63  COND     HLBL3,SINGLE $
64  SCE1     HUSET,HKNN,,,/HKFF,HKFS,HKSS,,, $
65  CHKPNT   HKFS,HKSS,HKFF $
66  LABEL    HLBL3 $
67  EQUIV    HKFF,HKAA/OMIT $

68  CHKPNT   HKAA $
69  COND     HLBL5,OMIT $
70  SMP1     HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $
71  CHKPNT   HGO,HKAA,HKOO,HLOO $
72  LABEL    HLBL5 $
73  EQUIV    HKAA,HKLL/REACT $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
74  CHKPNT   HKLL $
75  COND     HLBL6,REACT $
76  RBMG1    HUSET,HKAA,/HKLL,HKLR,HKRR,,, $
77  CHKPNT   HKLL,HKLR,HKRR $
78  LABEL    HLBL6 $
79  RBMG2    HKLL/HLLL $
80  CHKPNT   HLLL $
81  COND     HLBL7,REACT $
82  RBMG3    HLLL,HKLR,HKRR/HDM $
83  CHKPNT   HDM $
84  LABEL    HLBL7 $
85  SSG1     HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
             HLUSET/V,N,NSKIP $
86  CHKPNT   HPG $
87  EQUIV    HPG,HPL/NOSET $
88  CHKPNT   HPL $
89  COND     HLBL10,NOSET $
90  SSG2     HUSET,GM,YS,HKFS,HGO,HDM,HPG/HQR,HPO,HPS,HPL $
91  CHKPNT   HQR,HPO,HPS,HPL $
92  LABEL    HLBL10 $
93  SSG3     HLLL,HKLL,HPL,HLOO,HKOO,HPO/HULV,HUOOV,HRULV,HRUOV/V,N,OMIT/

             V,Y,IRES=-1/V,N,NSKIP/V,N,EPSI $
94  SAVE     EPSI $
95  CHKPNT   HULV,HUOOV,HRULV,HRUOV $
96  COND     HLBL9,IRES $
97  MATGPR   GPL,HUSET,HSIL,HRULV//C,N,L $
98  MATGPR   GPL,HUSET,HSIL,HRUOV//C,N,O $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  LABEL     HLBL9 $
100  SDR1      HUSET,HPG,HULV,HUOOV,YS,HGO,GM,HPS,HKFS,HKSS,HQR/HUGV,HPGG,HQG/
               V,N,NSKIP/C,N,HSTATICS $
101  CHKPNT    HUGV,HPGG,HQG $
102  COND      HLBL8,HREPEAT $
103  REPT      HLBL11,100 $
-------------------------------------------------------------- Bottom of DMAP Loop
104  JUMP      ERROR1 $
105  PARAM     //C,N,NOT/V,N,HTEST/V,N,HREPEAT $
106  COND      ERROR5,HTEST $
107  LABEL     HLBL8 $
108  CHKPNT    CSTM $
109  SDR2      CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDT,,HQG,HUGV,
               HEST,,HPGG/HOPG1,HOQG1,HOUGV1,HOES1,HOEF1,HPUGV1/C,N,STATICS $
110  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $
111  OFP       HOUGV1,HOPG1,HOQG1,HOEF1,HOES1,//V,N,CARDNO $
112  SAVE      CARDNO $
113  COND      HP2,JUMPPLOT $
114  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,HPUGV1,,HGPECT,
               HOES1/PLOTX2/V,N,HNSIL/V,N,LUSET/V,N,JUMPPLOT/V,N,   PLTFLG/V,
               N,PFILE $
115  SAVE      PFILE $
116  PRTMSG    PLOTX2// $

117  LABEL     HP2 $
118  JUMP      FINIS $
119  LABEL     ERROR1 $
120  PRTPARM   //C,N,-1/C,N,HSTA $
121  LABEL     ERROR3 $
122  PRTPARM   //C,N,-3/C,N,HSTA $
```

RIGID FORMAT DMAP LISTING
SERIES D

HEAT APPROACH, RIGID FORMAT 1

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
123  LABEL     ERROR4 $
124  PRTPARM   //C,N,-4/C,N,HSTA $
125  LABEL     ERROR5 $
126  PRTPARM   //C,N,-5/C,N,HSTA $
127  LABEL     FINIS $
128  END       $
```

3.17.2 Description of DMAP Operations for Static Heat Transfer Analysis

4. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external degree of freedom indices.

7. GP2 generates Element Connection Table with internal indices.

11. Go to DMAP No. 21 if no plot output is requested.

12. PLTSET transforms user input into a form used to drive structure plotter.

14. PRTMSG prints error messages associated with structure plotter.

17. Go to DMAP No. 21 if no undeformed boundary and structure (heat conduction) element plots are requested.

18. PLØT generates all requested undeformed boundary and heat conduction element plots.

20. PRTMSG prints plotter data and engineering data for each undeformed plot generated.

23. GP3 generates applied Static (Thermal) Loads Table (HSLT) and Grid Point Temperature Table.

25. TA1 generates element tables for use in matrix assembly, load generation, and data recovery.

27. Go to DMAP No. 123 and print error message if no elements have been defined.

30. Go to DMAP No. 38 if there are no heat conduction elements.

32. EMG generates element heat conduction matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no heat conduction matrix is to be assembled.

36. EMA assembles heat conduction matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

40. Go to next DMAP instruction if cold start or modified restart. LBL11 will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

41. Beginning of loop for additional constraint sets.

42. GP4 generates flags defining members of various displacement (temperature) sets (HUSET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$ and forms enforced temperature vector $\{Y_s\}$.

44. Go to DMAP No. 121 and print error message if no independent degrees of freedom are defined.

48. GPSP determines if possible grid point singularities remain.

50. Go to DMAP No. 52 if no grid point singularities remain.

51. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

53. Equivalence $[K_{gg}]$ to $[K_{nn}]$ if no multipoint constraints.

55. Go to DMAP No. 60 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

56. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

58. MCE2 partitions heat conduction matrix

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right]$$

and performs matrix reduction

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m].$$

61. Equivalence $[K_{nn}]$ to $[K_{ff}]$ if no single-point constraints.

63. Go to DMAP No. 66 if no single-point constraints.

64. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

67. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

69. Go to DMAP No. 72 if no omitted coordinates.

70. SMP1 partitions constrained heat conduction matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$

and performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

73. Equivalence $[K_{aa}]$ to $[K_{\ell\ell}]$ if no free-body supports.

75. Go to DMAP No. 78 if no free-body supports.

76. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] .$$

79. RBMG2 decomposes constrained heat conduction matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

81. Go to DMAP No. 84 if no free-body supports.

82. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}] ,$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates rigid body error ratio

$$\epsilon = \frac{||X||}{||K_{rr}||} .$$

85. SSG1 generates static thermal load vectors $\{P_g\}$.

87. Equivalence $\{P_g\}$ to $\{P_\ell\}$ if no constraints applied.

90. SSG2 applies constraints to static thermal load vectors

$$\{P_g\} = \left\{\begin{array}{c}\bar{P}_n \\ \hline P_m\end{array}\right\} , \qquad \{P_n\} = \{\bar{P}_n\} + [G_m^T]\{P_m\} ,$$

$$\{P_n\} = \left\{\begin{array}{c}\bar{P}_f \\ \hline P_s\end{array}\right\} , \qquad \{P_f\} = \{\bar{P}_f\} - [K_{fs}]\{Y_s\} ,$$

$$\{P_f\} = \left\{\begin{array}{c}\bar{P}_a \\ \hline P_o\end{array}\right\} , \qquad \{P_a\} = \{\bar{P}_a\} + [G_o^T]\{P_o\} ,$$

$$\{P_a\} = \left\{\begin{array}{c}P_\ell \\ \hline P_r\end{array}\right\}$$

and calculates determinate thermal powers $\{q_r\} = -\{P_r\} - [D^T]\{P_\ell\}$.

93. SSG3 solves for displacements of independent coordinates

$$\{u_\ell\} = [K_{\ell\ell}]^{-1}\{P_\ell\} ,$$

solves for displacements of omitted coordinates

$$\{u_o^o\} = [K_{oo}]^{-1}\{P_o\} ,$$

calculates residual vector (RULV) and residual vector error ratio for independent coordinates

$$\{\delta P_\ell\} = \{P_\ell\} - [K_{\ell\ell}]\{u_\ell\} \quad ,$$

$$\varepsilon_\ell = \frac{\{u_\ell^T\}\{\delta P_\ell\}}{\{P_\ell^T\}\{u_\ell\}}$$

and calculates residual vector (RUØV) and residual vector error ratio for omitted coordinates

$$\{\delta P_o\} = \{P_o\} - [K_{oo}]\{u_o^o\} \quad ,$$

$$\varepsilon_o = \frac{\{u_o^T\}\{\delta P_o\}}{\{P_o^T\}\{u_o^o\}} \quad .$$

96. Go to DMAP No. 99 if residual vectors are not to be printed.

97. MATGPR prints the residual vector for independent coordinates (HRULV).

98. MATGPR prints the residual vector for omitted coordinates (HRUØV).

100. SDR1 recovers dependent temperatures

$$\begin{Bmatrix} u_\ell \\ -- \\ u_r \end{Bmatrix} = \{u_a\} \quad , \qquad \{u_o\} = [G_o]\{u_a\} + \{u_o^o\} \quad ,$$

$$\begin{Bmatrix} u_a \\ -- \\ u_o \end{Bmatrix} = \{u_f\} \quad , \qquad \begin{Bmatrix} u_f \\ -- \\ Y_s \end{Bmatrix} = \{u_n\} \quad ,$$

$$\{u_m\} = [G_m]\{u_n\} \quad , \qquad \begin{Bmatrix} u_n \\ -- \\ u_m \end{Bmatrix} = \{u_g\} \quad ,$$

and recovers single-point powers of sustained thermal constraint

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\{u_f\} + [K_{ss}]\{Y_s\} \quad .$$

102. Go to DMAP No. 107 if all constraint sets have been processed.

103. Go to DMAP No. 41 if additional sets of constraints need to be processed.

104. Go to DMAP No. 119 and print error message if number of loops exceeds 100.

106. Go to DMAP No. 125 and print error message if multiple boundary conditions are attempted with improper subset.

109. SDR2 calculates conduction and boundary element heat flows and gradients (HØEF1) and prepares thermal load vectors (HØPG1), temperature vectors (HØUGV1) and single-point powers of constraint (HØQG1) for output plus element stresses (HØES1) and translation components of the temperature vector (HPUGV1).

111. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

113. Go to DMAP No. 117 if no temperature profile plots are requested.

114. PLØT generates all requested temperature profile and thermal contour plots.

116. PRTMSG prints plotter data, engineering data, and contour data for each temperature profile and thermal contour plot generated.

118. Go to DMAP No. 127 and make normal exit.

120. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

122. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

124. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

126. STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

3.17.3 Case Control Deck and Parameters for Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Static Heat Transfer Analysis:

1. A separate subcase must be defined for each unique combination of constraints and static loads.

2. A static loading condition must be defined for (not necessarily within) each subcase with a LØAD selection, unless all loading is specified with grid point temperatures on SPC cards.

3. An SPC set must be selected for (not necessarily within) each subcase, unless all constraints are specified on GRID cards or Scalar Connection cards.

4. Loading conditions associated with the same sets of constraints should be in contiguous subcases in order to avoid unnecessary looping.

5. REPCASE may be used to repeat subcases in order to allow multiple sets of the same output item.

The following output may be requested for Static Heat Transfer Analysis solutions:

1. Temperatures (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.

2. The punch option of a THERMAL request will produce TEMP bulk data cards.

3. Flux density (ELFØRCE) in selected elements.

4. Undeformed plots of the structural model and temperature profiles.

5. Contour plots of the thermal field.

The following parameters are used in Static Heat Transfer Analysis:

1. IRES - optional - a positive integer value of this parameter will cause the printing of the residual vectors following the execution of SSG3.

3.18 NONLINEAR STATIC HEAT TRANSFER ANALYSIS

3.18.1 DMAP Sequence for Nonlinear Static Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 3

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    NO.03 NONLINEAR STATIC HEAT TRANSFER ANALYSIS - SERIES 0 $

   2  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/   V,
               N,NOGPDT $

   3  SAVE     HLUSET $

   4  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL $

   5  GP2      GEOM2,HEQEXIN/ECT $

   6  CHKPNT   ECT $

   7  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

   8  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

   9  COND     HP1,NOPCDB $

  10  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,HNSIL/ V,N,
               JUMPPLOT=-1 $

  11  SAVE     HNSIL,JUMPPLOT $

  12  PRTMSG   PLTSETX// $

  13  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  14  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  15  COND     HP1,JUMPPLOT $

  16  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
               V,N,HNSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  17  SAVE     JUMPPLOT,PLTFLG,PFILE $

  18  PRTMSG   PLOTX1// $


  19  LABEL    HP1 $

  20  CHKPNT   PLTPAR,GPSETS,ELSETS $

  21  GP3      GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/V,N,NOGRAV $

  22  CHKPNT   HSLT,GPTT $

  23  TA1      ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
```

RIGID FORMAT DMAP LISTING
SERIES 0

HEAT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
              NOSIMP/C,N,1/V,N,NOGENL/V,N,HXYZ $

24  SAVE      NOSIMP $

25  COND      ERROR2,NOSIMP $

26  CHKPNT    HEST,HGPECT $

27  PARAM     //C,N,ADD/V,N,HNOKGG/C,N,1/C,N,0 $

28  EMG       HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,,/V,N,HNOKGG $

29  SAVE      HNOKGG $

30  CHKPNT    HKELM,HKDICT $

31  COND      JMPKGGX,HNOKGG $

32  EMA       HGPECT,HKDICT,HKELM/HKGGX,GPST $

33  CHKPNT    HKGGX,GPST $

34  LABEL     JMPKGGX $

35  RMG       HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
              V,N,HNLR/V,N,HLUSET $

36  SAVE      HNLR $

37  EQUIV     HKGGX,HKGG/HNLR $

38  PURGE     HQGE,HRGG/HNLR $

39  CHKPNT    HKGG,HQGE,HRGG $

40  GP4       CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/RG,YS,HUSET,HASET/ V,N,
              HLUSET/V,N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/    V,
              N,NSKIP/V,N,HREPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

41  SAVE      MPCF1,MPCF2,SINGLE,OMIT,REACT,NSKIP,HREPEAT,NOSET,NOL,NOA $


42  COND      ERROR1,NOL $

43  PURGE     GM/MPCF1/HPS,HKFS,HKSS,HKSF,HRSN,HQG/SINGLE $

44  CHKPNT    GM,HPS,HKFS,HKSS,HUSET,RG,HKSF,HRSN,YS $

45  GPSP      GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

46  SAVE      NOGPST $

47  COND      HLBL5,NOGPST $
```

RIGID FORMAT DMAP LISTING
SERIES 0

HEAT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  OFP      OGPST,,,,,// $

49  LABEL    HLBL5 $

50  EQUIV    HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1 $

51  CHKPNT   HKNN,HRNN $

52  COND     HLBL1,MPCF2 $

53  MCE1     HUSET,RG/GM $

54  CHKPNT   GM $

55  MCE2     HUSET,GM,HKGG,HRGG,,/HKNN,HRNN,, $

56  CHKPNT   HKNN,HRNN $

57  LABEL    HLBL1 $

58  EQUIV    HKNN,HKFF/SINGLE/HRNN,HRFN/SINGLE $

59  CHKPNT   HKFF,HRFN $

60  COND     HLBL2,SINGLE $

61  VEC      HUSET/VFS/C,N,N/C,N,F/C,N,S $

62  PARTN    HKNN,VFS,/HKFF,HKSF,HKFS,HKSS $

63  PARTN    HRNN,,VFS/HRFN,HRSN,,/C,N,1 $

64  LABEL    HLBL2 $

65  CHKPNT   HKFS,HKSS,HKFF,HKSF,HRFN,HRSN $

66  DECOMP   HKFF/HLLL,HULL/C,N,0/C,N,0/V,N,MDIAG/V,N,DET/V,N,PWR/V,N,
             KSING $

67  SAVE     KSING $


68  COND     ERROR3,KSING $

69  CHKPNT   HLLL,HULL $

70  SSG1     HSLT,BGPDT,CSTM,HSIL,HEST,MPT,GPTT,EDT,,CASECC,DIT/HPG/V,N,
             HLUSET/V,N,NSKIP $

71  CHKPNT   HPG $

72  EQUIV    HPG,HPF/NOSET $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  COND      HLBL3,NOSET $

74  SSG2      HUSET,GM,,HKFS,,,HPG/,,HPS,HPF $

75  LABEL     HLBL3 $

76  CHKPNT    HPF,HPS $

77  SSGHT     HUSET,HSIL,GPTT,GM,HEST,MPT,DIT,HPF,HPS,HKFF,HKFS,HKSF,   HKSS,
              HRFN,HRSN,HLLL,HULL/HUGV,HQG,HRULV/V,N,HNNLK=1/V,N,HNLR/   C,Y,
              EPSHT=.001/C,Y,TABS=0.0/C,Y,MAXIT=4/V,Y,IRES/V,N,   MPCF1/V,N,
              SINGLE $

78  CHKPNT    HUGV,HQG,HRULV $

79  COND      HLBL4,IRES $

80  MATGPR    GPL,HUSET,HSIL,HRULV//C,N,F $

81  LABEL     HLBL4 $

82  PLTTRAN   BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $

83  SAVE      HLUSEP $

84  CHKPNT    BGPDP,HSIP $

85  SDR2      CASECC,CSTM,MPT,DIT,HEQEXIN,HSIL,GPTT,EDT,BGPDP,,HQG,HUGV,
              HEST,,HPG/HOPG1,HOQG1,HOUGV1,HOES1,HOEF1,HPUGV1/C,N,STATICS $

86  PARAM     //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

87  OFP       HOUGV1,HOPG1,HOQG1,,,,//V,N,CARDNO $

88  SAVE      CARDNO $

89  SDRHT     HSIL,HUSET,HUGV,HOEF1,HSLT,HEST,DIT,HQGE,,/HOEF1X/C,Y,TABS/
              V,N,HNLR $

90  OFP       HOEF1X,,,,,//V,N,CARDNO $


91  SAVE      CARDNO $

92  COND      HP2,JUMPPLOT $

93  PLOT      PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,HPUGV1,,HGPECT,
              HOES1/PLOTX2/V,N,NSIL/V,N,HLUSEP/V,N,JUMPPLOT/   V,N,PLTFLG/V,
              N,PFILE $

94  PRTMSG    PLOTX2// $

95  LABEL     HP2 $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 3

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 96  JUMP      FINIS$
 97  LABEL     ERROR1 $
 98  PRTPARM   //C,N,-1/C,N,HNLI $
 99  LABEL     ERROR2 $
100  PRTPARM   //C,N,-2/C,N,HNLI $
101  LABEL     ERROR3 $
102  PRTPARM   //C,N,-3/C,N,HNLI $
103  LABEL     FINIS$
104  END       $
```

3.18.2 Description of DMAP Operations for Nonlinear Static Heat Transfer Analysis

2. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external degree of freedom indices.

5. GP2 generates the Element Connection Table with internal indices.

9. Go to DMAP No. 19 if no plot output is requested.

10. PLTSET transforms user input into a form used to drive structure plotter.

12. PRTMSG prints error messages associated with structure plotter.

15. Go to DMAP No. 19 if no undeformed boundary and structure (heat conduction) element plots are requested.

16. PLØT generates all requested undeformed boundary and heat conduction element plots.

18. PRTMSG prints plotter and engineering data for each generated plot.

21. GP3 generates applied Static (Heat Flux) Load Tables (HSLT) and the Grid Point Temperature Table.

23. TA1 generates element tables for use in matrix assembly, load generation, and heat flux data recovery.

25. Go to DMAP No. 99 and print error message if no elements have been defined.

28. EMG generates element heat conduction matrix tables and dictionaries for later assembly.

31. Go to DMAP No. 34 if no heat conduction matrix is to be assembled.

32. EMA assembles heat conduction matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

35. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the heat conduction matrix. The element radiation flux matrix, $[Q_{ge}]$, is also generated for use in recovery data for the HBDY elements.

37. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no linear component of radiation.

40. GP4 generates flags defining member of various displacement sets (HUSET) and forms multi-point constraint equations $[R_g]\{u_g\} = \{0\}$.

42. Go to DMAP No. 97 if no independent degrees of freedom are defined.

45. GPSP determines if possible grid point singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

47. Go to DMAP No. 49 if no Grid Point Singularity Table.

48. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

50. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[R_{gg}]$ to $[R_{nn}]$ if no multi-point constraints exist.

52. Go to DMAP No. 57 if no multi-point constraints exist.

53. MCE1 partitions the multi-point constraint equation matrix $[R_g] = [R_m \vdots R_n]$ and solves for the multi-point constraint transformation matrix

$$[G_m] = -[R_m]^{-1} [R_n].$$

55. MCE2 partitions heat conduction and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}^T] [G_m] + [G_m^T] [K_{mm}] [G_m] \text{ and}$$

$$[R_{nn}] = [\bar{R}_{nn}] + [G_m^T] [R_{mn}] + [R_{mn}^T] [G_m] + [G_m^T] [K_{mm}] [G_m].$$

58. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[R_{nn}]$ to $[R_{fn}]$ if no single-point constraints exist.

60. Go to DMAP No. 64 if no single-point constraints exist.

61. VEC generates a partitioning vector $\{u_n\} \rightarrow \{u_f\} + \{u_s\}$.

62. PARTN partitions the heat conduction matrix

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{fs} & K_{ss} \end{array}\right] .$$

63. PARTN partitions the radiation matrix

$$[R_{nn}] = \left[\begin{array}{c} R_{fn} \\ \hdashline R_{sn} \end{array}\right] .$$

66. DECØMP decomposes the potentially unsymmetric matrix $[K_{ff}]$ into upper and lower triangular factors $[U_{\ell\ell}]$ and $[L_{\ell\ell}]$.

68. Go to DMAP No. 101 if the matrix is singular.

70. SSG1 generates the input heat flux vector $\{P_g\}$.

72. Equivalence $\{P_g\}$ to $\{P_f\}$ if no constraints applied.

73. Go to DMAP No. 75 if no constraints of any kind exist.

74. SSG2 reduces the heat flux vector

$$\{P_g\} = \left\{\begin{array}{c} \bar{P}_n \\ \hdashline P_m \end{array}\right\} ,$$

$$\{P_n\} = \{\bar{P}_n\} + [G_m^T] \{P_m\} .$$

$$\{P_n\} = \begin{Bmatrix} P_f \\ \hdashline P_s \end{Bmatrix} .$$

77. SSGHT solves the nonlinear heat transfer problem by an iteration technique which is limited by parameters EPSHT and MAXIT. The output data blocks are: $\{u_g\}$, the solution temperature vector, $\{q_g\}$, the heat flux due to single-point constraints, and $\{\delta P_\ell\}$, the matrix of residual heat fluxes at each iteration step.

79. Go to DMAP No. 181 if residual vectors are not to be printed.

80. MATGPR prints the residual vectors for independent coordinates (HRULV).

82. PLTTRAN transforms the grid point definition tables into a special form for plotting temperature solutions when grid points with one degree of freedom are used.

85. SDR2 calculates the heat flux due to conduction and convection in the elements (HØEF1) and prepares the temperature vector (HØUGV1), the load vector (HØPG1), and the power of constraint (HØQG1) for output.

87. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

89. SDRHT processes the HBDY elements to produce heat flux into the elements (HØEF1X) due to convection, radiation, and applied flux.

90. ØFP formats the element flux table prepared by SDRHT and places it on the system output file for printing.

92. Go to DMAP No. 95 if no temperature profile plots are requested.

93. PLØT generates all requested temperature profile and thermal contour plots.

94. PRTMSG prints plotter data, engineering data, and contour data for each temperature profile and thermal contour plot generated.

96. Go to DMAP No. 103 and make normal exit.

98. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

100. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 2 - NØ SIMPLE STRUCTURAL ELEMENTS.

102. NØNLINEAR STATIC HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 3 - STIFFNESS MATRIX SINGULAR.

3.18.3 Case Control Deck and Parameters for Nonlinear Static Heat Transfer Analysis

The following items relate to subcase definition and data selection for Nonlinear Static Heat Transfer Analysis:

1. A single subcase must be defined with a single loading condition (LØAD) and a single constraint condition (SPC).

2. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP(MATERIAL) request. Temperatures for constrained components are taken from these TEMP cards and entries on SPC cards are ignored.

The following output may be requested for the last iteration in Nonlinear Static Heat Transfer Analysis:

1. Temperature (THERMAL) and nonzero components of static loads (ØLØAD) and constrained heat flow (SPCFØRCE) at selected grid points or scalar points.
2. The punch option of a THERMAL request will produce TEMP bulk data cards.
3. Flux density (ELFØRCE) in selected elements. In the case of CHBDY elements, a flux density summary is produced that includes applied flux, radiation flux, and convective flux.
4. Undeformed plots of the structural model and temperature profiles.
5. Contour plots of the thermal field.

The following parameters are used in Nonlinear Static Heat Transfer Analysis:

1. MAXIT - optional - the integer value of this parameter limits the maximum number of iterations. The default value is 4 iterations.

2. EPSHT - optional - the real value of this parameter is used to test the convergence of the solution. The default value is .001.

3. TABS - optional - the real value of this parameter is the absolute reference temperature. The default value is 0.0.

4. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant. The default value is 0.0.

5. IRES - optional - a positive value of this parameter will cause the printing of the residual vectors following the execution of SSGHT for each iteration.

3.19 TRANSIENT HEAT TRANSFER ANALYSIS

3.19.1 DMAP Sequence for Transient Heat Transfer Analysis

```
RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 9

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF  NOOSCAR

   1  BEGIN    NO.09 TRANSIENT HEAT TRANSFER ANALYSIS - SERIES O $

   2  FILE     HKGGX=TAPE/HKGG=TAPE $

   3  GP1      GEOM1,GEOM2,/GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL/V,N,HLUSET/   V,
               N,NOGPDT/V,N,ALWAYS=-1 $

   4  SAVE     HLUSET,NOGPDT $

   5  PURGE    HUSET,GM,HGO,HKAA,HBAA,HPSO,HKFS,HQP,HEST/NOGPDT $

   6  CHKPNT   GPL,HEQEXIN,GPDT,CSTM,BGPDT,HSIL,HUSET,GM,HGO,HKAA,HBAA, HPSO,
               HKFS,HQP,HEST $

   7  COND     HLBL5,NOGPDT $

   8  GP2      GEOM2,HEQEXIN/ECT $

   9  CHKPNT   ECT $

  10  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOPCDB $

  11  PURGE    PLTSETX,PLTPAR,GPSETS,ELSETS/NOPCDB $

  12  COND     HP1,NOPCDB $

  13  PLTSET   PCDB,HEQEXIN,ECT/PLTSETX,PLTPAR,GPSETS,ELSETS/V,N,NSIL/  V,N,
               JUMPPLOT=-1 $

  14  SAVE     NSIL,JUMPPLOT $

  15  PRTMSG   PLTSETX// $

  16  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,1/C,N,1 $

  17  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,0 $

  18  COND     HP1,JUMPPLOTS


  19  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIL,,ECT,,/PLOTX1/
               V,N,NSIL/V,N,HLUSET/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

  20  SAVE     JUMPPLOT,PLTFLG,PFILE $

  21  PRTMSG   PLOTX1// $

  22  LABEL    HP1 $
```

RIGID FORMAT DMAP LISTING
SERIES D

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  CHKPNT    PLTPAR,GPSETS,ELSETS $

24  GP3       GEOM3,HEQEXIN,GEOM2/HSLT,GPTT/C,N,1 $

25  CHKPNT    GPTT,HSLT $

26  TA1       ECT,EPT,BGPDT,HSIL,GPTT,CSTM/HEST,,HGPECT,/V,N,HLUSET/  V,N,
              NOSIMP=-1/C,N,1/C,N,123/C,N,123 $

27  SAVE      NOSIMP $

28  CHKPNT    HEST,HGPECT $

29  COND      HLBL1,NOSIMP $

30  PARAM     //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

31  PARAM     //C,N,ADD/V,N,NOBGG/C,N,1/C,N,0 $

32  EMG       HEST,CSTM,MPT,DIT,GEOM2,/HKELM,HKDICT,,,HBELM,HBDICT/V,N,
              NOKGGX/C,N,/V,N,NOBGG $

33  SAVE      NOKGGX,NOBGG $

34  CHKPNT    HKELM,HKDICT,HBELM,HBDICT $

35  COND      JMPKGGX,NOKGGX $

36  EMA       HGPECT,HKDICT,HKELM/HKGGX,GPST $

37  CHKPNT    HKGGX,GPST $

38  LABEL     JMPKGGX $

39  COND      JMPHBGG,NOBGG $

40  EMA       HGPECT,HBDICT,HBELM/HBGG, $

41  CHKPNT    HBGG $


42  LABEL     JMPHBGG $

43  PURGE     HBNN,HBFF,HBAA,HBGG/NOBGG $

44  CHKPNT    HBGG,HBNN,HBFF,HBAA $

45  LABEL     HLBL1 $

46  RMG       HEST,MATPOOL,GPTT,HKGGX/HRGG,HQGE,HKGG/C,Y,TABS/C,Y,SIGMA=0.0/
              V,N,HNLR/V,N,HLUSET $

47  SAVE      HNLR $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  EQUIV    HKGGX,HKGG/HNLR $

49  PURGE    HRGG,HRNN,HRFF,HRAA,HRDD/HNLR $

50  CHKPNT   HRGG,HRNN,HRFF,HRAA,HRDD,HKGG,HQGE $

51  GP4      CASECC,GEOM4,HEQEXIN,GPDT,BGPDT,CSTM/RG,,HUSET,ASET/V,N,HLUSET/
             V,N,MPCF1=-1/V,N,MPCF2=-1/V,N,SINGLE=-1/V,N,OMIT=-1/ V,N,REACT=
             -1/C,N,0/C,N,123/V,N,NOSET=-1/V,N,NOL/V,N,NOA=-1 $

52  SAVE     MPCF1,SINGLE,OMIT,NOSET,REACT,MPCF2,NOL,NOA $

53  PURGE    GM,GMD/MPCF1/HGO,HGOD/OMIT/HKFS,HPSO,HQP/SINGLE $

54  CHKPNT   GM,RG,HGO,HKFS,HQP,HUSET,GMD,HGOD,HPSO $

55  COND     HLBL2,NOSIMP $

56  GPSP     GPL,GPST,HUSET,HSIL/OGPST/V,N,NOGPST $

57  SAVE     NOGPST $

58  COND     HLBL2,NOGPST $

59  OFP      OGPST,,,,,// $

60  LABEL    HLBL2 $

61  EQUIV    HKGG,HKNN/MPCF1/HRGG,HRNN/MPCF1/HBGG,HBNN/MPCF1 $

62  CHKPNT   HKNN,HRNN,HBNN $

63  COND     HLBL3,MPCF1 $

64  MCE1     HUSET,RG/GM $

65  CHKPNT   GM $

66  MCE2     HUSET,GM,HKGG,HRGG,HBGG,/HKNN,HRNN,HBNN, $


67  CHKPNT   HKNN,HRNN,HBNN $

68  LABEL    HLBL3 $

69  EQUIV    HKNN,HKFF/SINGLE/HRNN,HRFF/SINGLE/HBNN,HBFF/SINGLE $

70  CHKPNT   HKFF,HRFF,HBFF $

71  COND     HLBL4,SINGLE $

72  SCE1     HUSET,HKNN,HRNN,HBNN,/HKFF,HKFS,,HRFF,HBFF, $
```

RIGID FORMAT DMAP LISTING
SERIES D

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  CHKPNT   HKFS,HKFF,HRFF,HBFF $

74  LABEL    HLBL4 $

75  EQUIV    HKFF,HKAA/OMIT $

76  EQUIV    HRFF,HRAA/OMIT $

77  EQUIV    HBFF,HBAA/OMIT $

78  CHKPNT   HKAA,HRAA,HBAA $

79  COND     HLBL3,OMIT $

80  SMP1     HUSET,HKFF,,,/HGO,HKAA,HKOO,HLOO,,,,, $

81  CHKPNT   HGO,HKAA $

82  COND     HLBLR,HNLR $

83  SMP2     HUSET,HGO,HRFF/HRAA $

84  CHKPNT   HRAA $

85  LABEL    HLBLR $

86  COND     HLBL5,NOBGG $

87  SMP2     HUSET,HGO,HBFF/HBAA $

88  CHKPNT   HBAA $

89  LABEL    HLBL5 $

90  DPD      DYNAMICS,GPL,HSIL,HUSET/GPLD,HSILD,HUSETD,TFPOOL,HDLT,,,HNLFT,
             HTRL,,HEQDYN/V,N,HLUSET/V,N,HLUSETD/C,N,123 /V,N,NODLT/   C,N,
             123/C,N,123/V,N,NONLFT/V,N,NOTRL/C,N,123/C,N,/V,N,NOUE $

91  SAVE     HLUSETD,NODLT,NONLFT,NOTRL,NOUE $


92  COND     ERROR1,NOTRL $

93  EQUIV    HGO,HGOD/NOUE/GM,GMD/NOUE $

94  PURGE    HPPO,HPSO,HPDO,HPDT/NODLT $

95  CHKPNT   HUSETD,HEQDYN,TFPOOL,HDLT,HTRL,HGOD,GMD,HNLFT,HSILD,GPLD,HPPO,
             HPSO,HPDO,HPDT $

96  MTRXIN   CASECC,MATPOOL,HEQDYN,,TFPOOL/HK2PP,,HB2PP/V,N,HLUSETD/  V,N,
             NOK2PP/C,N,123/V,N,NOB2PP $
```

RIGID FORMAT DMAP LISTING
SERIES D

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 97  SAVE     NOK2PP,NOB2PP $

 98  PARAM    //C,N,AND/V,N,KDEKA/V,N,NOUE/V,N,NOK2PP $

 99  PURGE    HK2DD/NOK2PP/HB2DD/NOB2PP $

100  EQUIV    HKAA,HKDD/KDEKA/HB2PP,HB2DD/NOA/HK2PP,HK2DD/NOA/HRAA,HRDD/
              NOUE $

101  CHKPNT   HK2PP,HB2PP,HK2DD,HB2DD,HKDD,HRDD $

102  COND     HLBL6,NOGPDT $

103  GKAD     HUSETD,GM,HGO,HKAA,HBAA,HRAA,,HK2PP,,HB2PP/HKDD,HBDD,  HRDD,
              GMD,HGOD,HK2DD,HM2DD,HB2DD/C,N,TRANRESP/C,N,DISP/C,N,  DIRECT/
              C,Y,G=0.0/C,Y,W3=0.0/C,Y,W4=0.0/V,N,NOK2PP/C,N,-1/   V,N,
              NOB2PP/V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/  C,N,-1/V,N,
              NOBGG/V,N,NOSIMP/C,N,-1 $

104  LABEL    HLBL6 $

105  EQUIV    HK2DD,HKDD/NOSIMP/HB2DD,HBDD/NOGPDT $

106  CHKPNT   HKDD,HBDD,HRDD,GMD,HGOD $

107  TRLG     CASECC,HUSETD,HDLT,HSLT,BGPDT,HSIL,CSTM,HTRL,DIT,GMD,HGOD,,
              HEST,/HPPO,HPSO,HPDO,HPDT,,HTOL/V,N,NOSET/V,N,PDEPDO $

108  SAVE     PDEPDO,NOSET $

109  EQUIV    HPPO,HPDO/NOSET $

110  EQUIV    HPDO,HPDT/PDEPDO $

111  CHKPNT   HPPO,HPDO,HPSO,HTOL,HPDT $

112  TRHT     CASECC,HUSETD,HNLFT,DIT,GPTT,HKDD,HBDD,HRDD,HPDT,HTRL/ HUDVT,
              HPNLD/C,Y,BETA=.55/C,Y,TABS=0.0/V,N,HNLR/C,Y,RADLIN=-1 $

113  CHKPNT   HUDVT,HPNLD $


114  VDR      CASECC,HEQDYN,HUSETD,HUDVT,HTOL,XYCDB,HPNLD/HOUDV1,HOPNL1/  C,
              N,TRANRESP/C,N,DIRECT/C,N,0/V,N,NOD/V,N,NOP/C,N,0 $

115  SAVE     NOD,NOP $

116  CHKPNT   HOUDV1,HOPNL1 $

117  COND     HLBL7,NOD $

118  SDR3     HOUDV1,HOPNL1,,,,/HOUDV2,HOPNL2,,,, $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
119  PARAM    //C,N,MPY/V,N,CARDNO/C,N,0/C,N,0 $

120  OFP      HOUDV2,HOPNL2,,,,//V,N,CARDNO $

121  SAVE     CARDNO $

122  CHKPNT   HOPNL2,HOUDV2 $

126  LABEL    HLBL7 $

127  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $

128  COND     HLBL9,PJUMP $

129  EQUIV    HUDVT,HUPV/NOA $

130  COND     HLBL8,NOA $

131  SDR1     HUSETD,,HUDVT,,,HGOD,GMD,HPSO,HKFS,,/HUPV,,HQP/C,N,1/C,N,
              TRANSNT $

132  LABEL    HLBL8 $

133  CHKPNT   HUPV,HQP $

134  PLTTRAN  BGPDT,HSIL/BGPDP,HSIP/V,N,HLUSET/V,N,HLUSEP $

135  SAVE     HLUSEP $

136  SDR2     CASECC,CSTM,MPT,DIT,HEQDYN,HSILD,,,BGPDP,HTOL,HQP,HUPV,HEST,
              XYCDB,HPPO/HOPP1,HOQP1,HOUPV1,,HOEF1,HPUGV/C,N,TRANRESP $

137  SDRHT    HSILD,HUSETD,HUPV,HOEF1,HSLT,HEST,DIT,HQGE,HDLT,/HOEF1X/C,,
              TABS/V,N,HNLR $

138  EQUIV    HOEF1X,HOEF1/ALWAYS $

139  SDR3     HOPP1,HOQP1,HOUPV1,,HOEF1,/HOPP2,HOQP2,HOUPV2,,HOEF2, $

140  CHKPNT   HOPP2,HOQP2,HOUPV2,HOEF2 $


141  OFP      HOPP2,HOQP2,HOUPV2,HOEF2,,//V,N,CARDNO $

142  SAVE     CARDNO $

143  COND     HP2,JUMPPLOT $

144  PLOT     PLTPAR,GPSETS,ELSETS,CASECC,BGPDT,HEQEXIN,HSIP,,HPUGV, HGPECT,/
              PLOTX2/V,N,HNSIL/V,N,HLUSEP/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

145  SAVE     PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES O

HEAT APPROACH, RIGID FORMAT 9

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
146  PRTMSG    PLOTX2// $

147  LABEL     HP2 $

148  XYTRAN    XYCDB,HOPP2,HOQP2,HOUPV2,,HOEF2/HXYPLTT/C,N,TRAN/C,N,PSET/V,N,
               PFILE/V,N,CARDNO $

149  SAVE      PFILE,CARDNO $

150  XYPLOT    HXYPLTT// $

151  LABEL     HLBL9 $

152  JUMP      FINIS $

153  LABEL     ERROR1 $

154  PRTPARM   //C,N,-1/C,N,HTRD $

155  LABEL     FINIS$

156  END       $
```

3.19.2 Description of DMAP Operations for Transient Heat Transfer Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external degree of freedom indices.

7. Go to DMAP No. 89 if no grid point definition table.

8. GP2 generates the Element Connection Table with internal indices.

12. Go to DMAP No. 22 if no plot output is requested.

13. PLTSET transforms user input into a form used to drive the structure plotter.

15. PRTMSG prints error messages associated with the structure plotter.

18. Go to DMAP No. 22 if no undeformed boundary and structure (heat conduction) element plots are requested.

19. PLØT generates all requested undeformed boundary and heat conduction element plots.

21. PRTMSG prints plotter data and engineering data for each generated plot.

24. GP3 generates applied Static (Heat Flux) Load Tables (HSLT) and the Grid Point Temperature Table.

26. TA1 generates element tables for use in matrix assembly, load generation, and data recovery.

29. Go to DMAP No. 45 if no heat conduction or boundary elements exist.

32. EMG generates element heat conduction and capacitance matrix tables and dictionaries for later assembly.

35. Go to DMAP No. 38 if no heat conduction matrix is to be assembled.

36. EMA assembles heat conduction matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

39. Go to DMAP No. 42 if no heat capacitance matrix is to be assembled.

40. EMA assembles heat capacitance matrix $[B_{gg}]$.

46. RMG generates the radiation matrix, $[R_{gg}]$, and adds the estimated linear component of radiation to the conductivity matrix. The element-radiation flux matrix, $[Q_{ge}]$, is also generated for use in data recovery.

48. Equivalence the linear heat transfer matrix, $[K_{gg}]$, to the heat conduction matrix if no radiation exists.

51. GP4 generates flags defining members of various displacement sets (HUSET) and forms the multi-point constraint equations, $[R_g]\{u_g\} = 0$.

55. Go to DMAP No. 60 if no simple elements exist.

56. GPSP determines if possible grid point singularities remain. These may be extraneous in a radiation problem, since some points may transfer heat through radiation only.

58. Go to DMAP No. 60 if no Grid Point Singularity Table.

59. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

61. Equivalence $[K_{gg}]$ to $[K_{nn}]$, $[R_{gg}]$ to $[R_{nn}]$, and $[B_{gg}]$ to $[B_{nn}]$ if no multi-point constraints exist.

63. Go to DMAP No. 68 if no multi-point constraints exist.

64. MCE1 partitions the multi-point constraint equation matrix, $[R_g] = [R_m \vdots R_n]$, and solves for the multi-point constraint transformation matrix,

$$[G_m] = -[R_m]^{-1} [R_n].$$

66. MCE2 partitions heat conduction and radiation matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] ,$$

$$[R_{gg}] = \left[\begin{array}{c|c} \bar{R}_{nn} & R_{nm} \\ \hline R_{mn} & R_{mm} \end{array}\right] ,$$

$$[B_{gg}] = \left[\begin{array}{c|c} \bar{B}_{nn} & B_{nm} \\ \hline B_{mn} & B_{mm} \end{array}\right] ,$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T] [K_{mn}] + [K_{mn}] [G_m] + [G_m^T] [K_{mm}] [G_m].$$

The same equation is applied to $[R_{nn}]$ and $[B_{nn}]$.

69. Equivalence $[K_{nn}]$ to $[K_{ff}]$, $[B_{nn}]$ to $[B_{ff}]$, and $[R_{nn}]$ to $[R_{ff}]$ if no single-point constraints exist.

71. Go to DMAP No. 74 if no single-point constraints exist.

72. SCE1 partitions the matrices as follows:

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] .$$

$[R_{nn}]$ and $[B_{nn}]$ are partitioned in the same manner, except only the ff partitions are saved.

75. Equivalence $[K_{ff}]$ to $[K_{aa}]$ if no omitted coordinates.

76. Equivalence $[R_{ff}]$ to $[R_{aa}]$ if no omitted coordinates.

77. Equivalence $[B_{ff}]$ to $[B_{aa}]$ if no omitted coordinates.

79. Go to DMAP No. 89 if no omitted coordinates are requested.

80. SMP1 partitions the heat conduction matrix

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right] ,$$

solves for the transformation matrix $[G_o]$:

$$[K_{oo}]\,[G_o] = -\,[K_{oa}] ,$$

and solves for the reduced heat conduction matrix $[K_{aa}]$:

$$[K_{aa}] = [\bar{K}_{aa}] + [K_{ao}]\,[G_o] .$$

82. Go to DMAP No. 85 if no radiation matrix exists.

83. SMP2 partitions constrained radiation matrix

$$[R_{ff}] = \left[\begin{array}{c|c} \bar{R}_{aa} & R_{ao} \\ \hline R_{oa} & R_{oo} \end{array}\right] ,$$

and performs matrix reduction

$$[R_{aa}] = [\bar{R}_{aa}] + [R_{oa}^T]\,[G_o] + [G_o^T]\,[R_{oa}] + [G_o^T]\,[R_{oo}]\,[G_o].$$

86. Go to DMAP No. 89 if no heat capacitance matrix, $[B_{ff}]$, exists.

87. SMP2 calculates a reduced heat capacitance matrix, $[B_{aa}]$, with the same equation as DMAP No. 83.

90. DPD generates the table defining the displacement sets each degree of freedom belongs to (HUSETD), including extra points. It prepares the Transfer Function Pool, the Dynamics Load Table, the Nonlinear Function Table, and the Transient Response List.

92. Go to DMAP No. 153 and exit if no time step data was specified.

93. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points were defined.

96. MTRXIN selects the direct input matrices $[K_{pp}^2]$ and $[B_{pp}^2]$.

100. Equivalence $[K_{aa}]$ to $[K_{dd}^1]$ if no direct input stiffness matrices and no extra points; $[B_{pp}]$ to $[B_{dd}^2]$ and $[K_{pp}]$ to $[K_{dd}^2]$ if only extra points are used; and $[R_{aa}]$ to $[R_{dd}]$ if no extra points are used.

102. Go to DMAP No. 104 if no grid point definition table.

103. GKAD expands the matrices to include extra points and assembles heat conduction, capacitance, and radiation matrices for use in Direct Transient Response.

$$[K^1_{dd}] = \left[\begin{array}{c|c} K_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[B^1_{dd}] = \left[\begin{array}{c|c} B_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

$$[R_{dd}] = \left[\begin{array}{c|c} R_{aa} & 0 \\ \hline 0 & 0 \end{array}\right] ,$$

and

$$[K_{dd}] = [K^1_{dd}] + [K^2_{dd}] ,$$

$$[B_{dd}] = [B^1_{dd}] + [B^2_{dd}] .$$

(Nonzero values of the parameters W4, G, and W3 are not recommended for use in heat transfer analysis and therefore do not appear in the above equations.)

105. Equivalence $[K^2_{dd}]$ to $[K_{dd}]$ and $[B^2_{dd}]$ to $[B_{dd}]$ if no matrices were generated from the element heat conduction and capacitance assemblers.

107. TRLG generates matrices of heat flux loads versus time. $\{P^o_p\}$, $\{P^o_s\}$, and $\{P^o_d\}$ are generated with one column per output time step. $\{P^t_d\}$ is generated with one column per solution time step, and the Transient Output List is a list of output time steps.

109. Equivalence $\{P^o_p\}$ to $\{P^o_d\}$ if the d and p sets are the same.

110. Equivalence $\{P^o_d\}$ to $\{P^t_d\}$ if the output times are the same as the solution times.

112. TRHT integrates the equation of motion:

$$[B_{dd}]\{\dot{u}\} + [K_{dd}]\{u\} = \{P_d\} + \{N_d\} .$$

where $\{u\}$ is a vector of temperatures at any time,
$\{\dot{u}\}$ is the time derivative of $\{u\}$ ("velocity"),
$\{P_d\}$ is the applied heat flux at any time step, and
$\{N_d\}$ is the total nonlinear heat flux from radiation and/or NØLIN data, extrapolated from the previous solution vector.

The output consists of the $[u^t_d]$ matrix containing temperature vectors and temperature "velocity" vectors for the output time steps.

114. VDR prepares the solution set temperatures, temperature "velocities", and nonlinear loads, sorted by time step, for output.

117. Go to DMAP No. 126 if no output request for solution set.

118. SDR3 prepares the requested output of temperatures, temperature "velocities", and nonlinear loads sorted by point number or element number.

120. ØFP formats the tables prepared by SDR3 for output sorted by point number or element number and places them on the system output file for printing.

128. Go to DMAP No. 151 and exit if no further output is requested.

129. Equivalence $\{u_d\}$ to $\{u_p\}$ if no structure points were input.

130. Go to DMAP No. 132 if no structure points were input.

131. SDR1 recovers the dependent temperatures:

$$\{u_o\} = [G_o^d]\,\{u_d\}\ ,$$

$$\begin{Bmatrix} u_d \\ \hline u_o \end{Bmatrix} = \{u_f\}\ ,$$

$$\begin{Bmatrix} u_f+u_e \\ \hline u_s \end{Bmatrix} = \{u_n\}\ ,$$

$$\{u_m\} = [G_m^d]\,\{u_f+u_e\}\ ,$$

$$\begin{Bmatrix} u_n+u_e \\ \hline u_m \end{Bmatrix} = \{u_p\}\ .$$

The module also recovers the heat flux into the points having single-point constraints.

$$\{q_s\} = -\{P_s\} + [K_{fs}^T]\,\{u_f\}.$$

134. PLTTRAN coverts the grid point definition tables into a special form for plotting temperature solutions when grid points with one degree of freedom are used.

136. SDR2 calculates requested heat flux transfer in the elements and prepares temperatures, "velocities", and heat flux loads for output sorted by time step.

139. SDR3 prepares requested output sorted by point number or element number.

141. ØFP formats tables prepared by SDR3 for output and places them on the system output file for printing.

143. Go to DMAP No. 147 if no temperature profile plots are requested.

144. PLØT generates all requested temperature profile plots and thermal contours for specified times.

146. PRTMSG prints plotter data, engineering data, and contour data for each temperature profile and thermal contour plot generated.

148. XYTRAN prepares the input for requested X-Y plots.

150. XYPLØT prepares requested X-Y plots of temperatures, "velocities", element flux, or applied heat loads versus time.

152. Go to DMAP No. 155 and make normal exit.

154. TRANSIENT HEAT TRANSFER ANALYSIS ERRØR MESSAGE NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

3.19.3 Case Control Deck and Parameters for Transient Heat Transfer Analysis

The following items relate to subcase definition and data selection for Transient Heat Transfer Analysis:

1. A single subcase must be defined with a single constraint condition.

2. DLØAD and/or NØNLINEAR must be used to define a single time-dependent loading condition. The static load cards (QVECT, QVØL, QHBDY, QBDY1, and QBDY2) can be used to define a dynamic load by using these cards with, or instead of, the DAREA cards. The set identification number on the static load cards (field 2) is used in the same manner as the set identification number on the DAREA cards (field 2).

3. TSTEP must be used to select the time-step intervals to be used for integration and output.

4. If nonzero initial conditions are desired, IC must be used to select a TEMP set in the Bulk Data Deck.

5. An estimated temperature distribution vector must be defined on TEMP cards and selected with a TEMP (MATERIAL) request if radiation effects are included.

The following printed output, sorted by point number or element number (SØRT2), is available at selected multiples of the integration time step:

1. Temperatures (THERMAL) and derivatives of temperatures (VELØCITY) for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SDISPLACEMENT and SVELØCITY for SØLUTIØN points (points used in formation of dynamic equation).

2. Nonzero components of the applied load vector (ØLØAD) and constrained heat flow (SPCFØRCE) for a list of PHYSICAL points.

3. Nonlinear load vector for a list of SØLUTIØN points.

4. Flux density (ELFØRCE) in selected elements.

The following plotter output is available for Transient Heat Transfer Analysis:

1. Undeformed plot of the structural model.

2. Temperature profiles and thermal contours for selected time intervals.

3. X-Y plot of temperature or derivative of temperature for a PHYSICAL point or SØLUTIØN point.

4. X-Y plot of the applied load vector, nonlinear load vector, or constrained heat flow.

5. X-Y plot of flux density for an element.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Transient Heat Transfer Analysis:

1. TABS - optional - the real value of this parameter is the absolute reference temperature. The default value is 0.0.

2. SIGMA - optional - the real value of this parameter is the Stefan-Boltzmann constant. The default value is 0.0.

3. BETA - optional - the real value of this parameter is used as a factor in the integration algorithm (see section 8.4.2 of the Theoretical Manual). The default value is 0.55.

4. RADLIN - optional - a positive integer value of this parameter causes some of the radiation effects to be linearized (see Equation 2, Section 8.4.2 of the Theoretical Manual). The default value is -1.

3.20 MODAL FLUTTER ANALYSIS

3.20.1 DMAP Sequence for Modal Flutter Analysis

```
RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT: GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

   1  BEGIN    AERO NO. 10 MODAL FLUTTER ANALYSIS SERIES 0 $

   2  FILE     PHIHL=APPEND/AJJL=APPEND/FSAVE=APPEND/CASEYY=APPEND/CLAMAL=
               APPEND/ OVG=APPEND/QHHL=APPEND/SKJ=APPEND/QHJL=APPEND/QKHL=
               APPEND/ $

   3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
               NOGPDT $

   4  SAVE     LUSET,NOGPDT $

   5  COND     ERROR1,NOGPDT $

   6  GP2      GEOM2,EQEXIN/ECT $

   7  PARAML   PCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,JUMPPLOT $

   8  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

   9  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
               NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

  10  SAVE     NOGENL,NOSIMP,GENEL $

  11  COND     ERROR1,NOSIMP $

  12  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

  13  PARAM    //C,N,ADD/V,N,NOMGG /C,N,1/C,N,0 $

  14  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
               N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
               CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
               CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $

  15  SAVE     NOKGGX,NOMGG $

  16  COND     JMPKGGX,NOKGGX $


  17  EMA      GPECT,KDICT,KELM/KGGX,GPST $

  18  CHKPNT   KGGX,GPST $

  19  LABEL    JMPKGGX $

  20  COND     ERROR1,NOMGG $

  21  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $
```

RIGID FORMAT DMAP LISTING
SERIES D

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
22  CHKPNT   MGG $

23  COND     LGPWG,GRDPNT $

24  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

25  OFP      OGPWG,,,,,//V,N,CARDNO $

26  LABEL    LGPWG $

27  EQUIV    KGGX,KGG/NOGENL $

28  CHKPNT   KGG $

29  COND     LBL11,NOGENL $

30  SMA3     GEI,/KGGY/V,N,LUSET/V,N,NOGENL/C,N,-1 $

31  CHKPNT   KGGY $

32  ADD      KGGX,KGGY/KGG $

33  CHKPNT   KGG $

34  LABEL    LBL11 $

35  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/V,N,LUSET/V,
             N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/REPEAT/V,
             N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

36  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2, REPEAT,NOL,NOA $

37  CHKPNT   RG,USET $

38  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $

39  SAVE     NOGPST $

40  COND     LBL4,NOGPST $


41  OFP      OGPST,,,,,//V,N,CARDNO $

42  LABEL    LBL4 $

43  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

44  COND     LBL2,MPCF1 $

45  MCE1     USET,RG/GM $

46  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
```

MODAL FLUTTER ANALYSIS

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
47  CHKPNT   KNN,MNN $

48  LABEL    LBL2 $

49  CHKPNT   GM $

50  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $

51  COND     LBL3,SINGLE $

52  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $

53  LABEL    LBL3 $

54  CHKPNT   KFS,KFF,MFF $

55  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $

56  CHKPNT   KAA,MAA $

57  PURGE    GO/OMIT $

58  CHKPNT   GO $

59  COND     LBL5,OMIT $

60  PARAM    //C,N,PREC/V,N,PREC $

61  VEC      USET/V/C,N,F/C,N,O/C,N,A $

62  PARTN    KFF,V,/KOO,,KOA,KAAB $

63  CHKPNT   KOO,KOA,KAAB $

64  DECOMP   KOO/LOO,UOO/C,N,1/C,N,0/V,N,MIND/V,N,DET/V,N,NDET/V,N,SING $

65  SAVE     MIND,DET,NDET,SING $

66  COND     LSING,SING $


67  LABEL    LSING $

68  JUMP     CONT $

69  PRTPARM  //C,N,0 $

70  LABEL    CONT $

71  CHKPNT   LOO,UOO $

72  FBS      LOO,UOO,KOA/GO/C,N,1/C,N,-1/V,N,PREC/V,N,PREC $
```

RIGID FORMAT DMAP LISTING
SERIES D

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
73  CHKPNT   GO $

74  MPYAD    KOA,GO,KAAB/KAA/C,N,1/C,N,1/C,N,1/V,N,PREC $

75  CHKPNT   KAA $

76  SMP2     USET,GO,MFF/MAA $

77  CHKPNT   MAA $

78  LABEL    LBL5 $

79  COND     LBL6,REACT $

80  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

81  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

82  RBMG2    KLL/LLL/ $

83  CHKPNT   LLL $

84  RBMG3    LLL,KLR,KRR/DM $

85  CHKPNT   DM $

86  RBMG4    DM,MLL,MLR,MRR/MR $

87  CHKPNT   MR $

88  LABEL    LBL6 $

89  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,,,,,,EED,EQDYN/V,
             N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/V,N,NOFRL/V,
             N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $

90  SAVE     LUSETD,NOUE,NOEED $

91  COND     ERROR2,NOEED $


92  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

93  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
             NEIGV $

94  SAVE     NEIGV $

95  CHKPNT   LAMA,PHIA,MI,OEIGS $

96  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

97  COND     ERROR4,NEIGV $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 98  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

 99  SAVE     NOK2PP,NOM2PP,NOB2PP $

100  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA $

101  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

102  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/C,
              N,-1/C,N,-1/ C,N,-1/C,N,-1 $

103  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

104  GKAM     USETD,PHIA,,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/V,
              N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0./C,Y,HFREQ=0./V,N,  NOM2PP/V,N,
              NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP $

105  SAVE     NONCUP,FMODE $

106  CHKPNT   MHH,BHH,KHH,PHIDH $

107  APD      EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
              USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
              N,LUSETA/V,N,BOV $

108  SAVE     NK,NJ,LUSETA,BOV $

109  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $

110  COND     SKPPLT,JUMPPLOT $

111  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $

112  PLTSET   PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
              JUMPPLOT $

113  SAVE     NSIL1,JUMPPLOT $


114  PRTMSG   PLTSETA // $

115  COND     SKPPLT,JUMPPLOT $

116  PLOT     PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO, ,,,,/PLOTX2/V,N,
              NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $

117  SAVE     PFILE,JUMPPLOT,PLTFLG $

118  PRTMSG   PLOTX2 // $
```

RIGID FORMAT DMAP LISTING
SERIES D

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
119  LABEL    SKPPLT $

120  COND     ERROR2,NOEED $

121  GI       SPLINE,USET ,CSTMA,BGPA,SIL , ,GM,GO/GTKA/V,N,NK/V,N,LUSET $

122  CHKPNT   GTKA $

123  PARAM    //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1/ $

124  AMG      AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY/ $

125  SAVE     DESTRY $

126  CHKPNT   AJJL,SKJ,D1JK,D2JK $

127  COND     NODJE,NODJE $

128  INPUTT2  /D1JE,D2JE,,,,/C,Y,P1=-1/C,Y,P2=11/C,Y,P3=XXXXXXXX $

129  LABEL    NODJE $

130  PARAM    //C,N,ADD/V,N,XQHHL /C,N,1/C,N,0 $

131  AMP      AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,QKHL,
              QHJL/V,N,NOUE/V,N,XQHHL/V,Y,GUSTAERO=+1 $

132  SAVE     XQHHL $

133  CHKPNT   QHHL,QKHL,QHJL $

134  PARAM    //C,N,MPY/V,N,NOP/C,N,-1 /C,N,1 $

135  PARAM    //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $

136  PARAM    //C,N,MPY/V,N,NOH/C,N,0/C,N,1 $

137  PARAM    //C,N,MPY/V,N,FLOOP/V,Y,NODJE=-1/C,N,0 $

138  JUMP     LOOPTOP $
```

Top of DMAP Loop

```
139  LABEL    LOOPTOP $

140  FA1      KHH,BHH,MHH,QHHL,CASECC,FLIST/FSAVE,KXHH,BXHH,MXHH/V,N,FLOOP/
              V,N,TSTART/V,N,NOCEAD $

141  SAVE     FLOOP,TSTART,NOCEAD $

142  CHKPNT   FSAVE,KXHH,BXHH,MXHH $

143  EQUIV    KXHH,PHIH/NOCEAD/BXHH,CLAMA/NOCEAD/KXHH,PHIHL/NOCEAD/BXHH,
              CLAMAL/NOCEAD/CASECC,CASEYY/NOCEAD $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
144  CHKPNT   PHIH,CLAMA,PHIHL,CLAMAL,CASEYY $

145  COND     VDR,NOCEAD $

146  CEAD     KXHH,BXHH,MXHH,EED,CASECC/PHIH,CLAMA,OCEIGS/V,N,EIGVS $

147  SAVE     EIGVS $

148  COND     LBLZAP,EIGVS $

149  LABEL    VDR $

150  COND     LBL16,NOH $

151  VDR      CASECC,EQDYN ,USETD,PHIH,CLAMA,,/OPHIH,/C,N,CEIGEN/C,N,MODAL/C,
              N,   123/V,N,NOH /V,N,NOP/V,N,FMODE $

152  SAVE     NOH,NOP $

153  COND     LBL16,NOH $

154  OFP      OPHIH,,,,,//V,N,CARDNO $

155  SAVE     CARDNO $

156  LABEL    LBL16 $

157  FA2      PHIH,CLAMA ,FSAVE/PHIHL,CLAMAL,CASEYY,OVG/V,N,TSTART/   C,Y,
              VREF=1.0/C,Y,PRINT=YES $

158  SAVE     TSTART $

159  CHKPNT   PHIHL,CLAMAL,CASEYY,OVG $

160  COND     CONTINUE,TSTART $

161  LABEL    LBLZAP $

162  COND     CONTINUE,FLOOP $
```

Bottom of DMAP Loop

```
163  REPT     LOOPTOP,100 $

164  JUMP     ERROR3 $

165  LABEL    CONTINUE $

166  CHKPNT   OVG $

167  PARAML   XYCDB//C,N,PRES/C,N,/C,N,/C,N,/V,N,NOXYCDB $

168  COND     NOXYOUT,NOXYCDB $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
169  XYTRAN   XYCDB,OVG,,,,/XYPLTCE/C,N,VG/C,N,PSET/V,N,PFILE/V,N,CARDNO/  V,
              N,NOXYPL $

170  SAVE     PFILE,CARDNO,NOXYPL $

171  COND     NOXYOUT,NOXYPL $

172  XYPLOT   XYPLTCE// $

173  LABEL    NOXYOUT $

174  PARAM    //C,N,AND/V,N,PJUMP/V,N,NOP=-1/V,N,JUMPPLOT $

175  COND     FINIS,PJUMP $

176  MODACC   CASEYY,CLAMAL,PHIHL,,,/CLAMAL1,CPHIH1,CASEZZ,,/C,N,CEIGN $

177  ADR      CPHIH1,CASEZZ,QKHL,CLAMAL1,SPLINE,SILA,USETA/PKF/V,N,BOV/   C,
              Y,MACH = 0.0/C,N,FLUTTER $

176  DDR1     CPHIH1,PHIDH/CPHID $

179  CHKPNT   CPHID $

180  EQUIV    CPHID ,CPHIP/NOA $

181  COND     LBL14,NOA $

182  SDR1     USETD,,CPHID ,,,GOD,GMD,,KFS,,/CPHIP,,QPC/C,N,1 /C,N,DYNAMICS $

183  LABEL    LBL14 $

184  CHKPNT   CPHIP,QPC $

185  EQUIV    CPHID ,CPHIA/NOUE $

186  COND     LBLNOE,NOUE $

187  VEC      USETA/PP/C,N,D/C,N,A/C,N,E $


188  PARTN    CPHID ,,RP/CPHIA,,,/C,N,1/C,N,3 $

189  LABEL    LBLNOE $

190  MPYAD    GTKA,CPHIA,/CPHIK/C,N,1/C,N,1/C,N,0/V,N,PREC $

191  UMERGE   USETA,CPHIP,/CPHIPS/C,N,PS/C,N,P/C,N,SA $

192  UMERGE   USETA,CPHIPS,CPHIK/CPHIPA/C,N,PA/C,N,PS/C,N,K $

193  CHKPNT   CPHIPA $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 10

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
194  UMERGE    USETA,QPC,/QPAC/C,N,PA/C,N,P/C,N,K $

195  CHKPNT    QPAC $

196  SDR2      CASEZZ,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,CLAMAL1,QPAC,CPHIPA,
               EST,,/,OQPAC1,OCPHIPA,OESC1,OEFC1,PCPHIPA/C,N,CEIGN $

197  CHKPNT    PCPHIPA $

198  OFP       OCPHIPA,OQPAC1,OESC1,OEFC1,,//V,N,CARDNO $

199  COND      FINIS,JUMPPLOT $

200  PLOT      PLTPARA,GPSETSA,ELSETSA,CASEZZ,BGPA,EQAERO,SILGA,,PCPHIPA, ,
               /PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,
               PFILE $

201  PRTMSG    PLOTX3// $

202  JUMP      FINIS $

203  LABEL     ERROR3 $

204  PRTPARM   //C,N,-3/C,N,FLUTTER $

205  LABEL     ERROR2 $

206  PRTPARM   //C,N,-2/C,N,FLUTTER $

207  LABEL     ERROR1 $

208  PRTPARM   //C,N,-1/C,N,FLUTTER $

209  LABEL     ERROR4 $

210  PRTPARM   //C,N,-4/C,N,FLUTTER $

211  LABEL     FINIS $

212  END       $
```

3.20.2 Description of DMAP Operations for Modal Flutter Analysis

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. Go to DMAP No. 207 and print error message if no grid points are present.

6. GP2 generates Element Connection Table with internal indices.

8. GP3 generates Static Loads Table and Grid Point Temperature Table.

9. TA1 generates element tables for use in matrix assembly and stress recovery.

11. Go to DMAP No. 207 and print error message if no elements have been defined.

14. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

16. Go to DMAP No. 19 if no stiffness matrix is to be assembled.

17. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

20. Go to DMAP No. 207 and print error message if no mass matrix exists.

21. EMA assembles mass matrix $[M_{gg}]$.

23. Go to DMAP No. 26 if no weight and balance request.

24. GPWG generates weight and balance information.

25. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

27. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

29. Go to DMAP No. 34 if no general elements.

30. SMA3 forms the general element stiffness matrix $[K^y_{gg}]$.

32. ADD combines the structural stiffness matrix $[K^x_{gg}]$ with the general element stiffness matrix $[K^y_{gg}]$ to obtain the stiffness matrix $[K_{gg}]$.

35. GP4 generates flags defining members of various displacement sets (USET), forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

38. GPSP determines if possible grid point singularities remain.

40. Go to DMAP No. 42 if no grid point singularities remain.

41. ØFP formats the table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

43. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

44. Go to DMAP No. 48 if MCE1 and MCE2 have already been executed for current set of multipoint constraints.

45. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \vdots R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

46. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m] \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] \;.$$

50. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

51. Go to DMAP No. 53 if no single-point constraints.

52. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

55. Equivalence $[K_{ff}]$ to $[K_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

59. Go to DMAP No. 78 if no omitted coordinates.

61. VEC generates an f-size partitioning vector (V) for the o- and a-sets.

$$\{u_f\} \rightarrow \{u_o\} + \{u_a\}$$

62. PARTN partitions constrained stiffness matrix using V.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

64. DECØMP decomposes $[K_{oo}]$ into upper and lower triangular factors $[U_{oo}]$ and $[L_{oo}]$.

72. FBS solves for the transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$.

74. MPYAD performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

76. SMP2 partitions constrained mass matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}] .$$

79. Go to DMAP No. 88 if no free-body supports.

80. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \quad \text{and} \quad [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

82. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

84. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates and outputs rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

86. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

89. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal and external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

91. Go to DMAP No. 205 and print error message if no Eigenvalue Extraction Data.

92. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

93. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0 ,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \left[\begin{array}{c} D\,\phi_{ro} \\ \hline \phi_{ro} \end{array}\right] ,$$

calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass

96. ØFP formats the summary of eigenvalues (LAMA) and the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

97. Go to DMAP No. 210 and print error message if no eigenvalues are found.

98. MTRXIN selects the direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$.

100. Equivalence $[M^2_{pp}]$ to $[M^2_{dd}]$, $[B^2_{pp}]$ to $[B^2_{dd}]$ and $[K^2_{pp}]$ to $[K^2_{dd}]$ if no constraints applied.

102. GKAD applies constraints to direct input matrices $[K^2_{pp}]$, $[M^2_{pp}]$, and $[B^2_{pp}]$, forming $[K^2_{dd}]$, $[M^2_{dd}]$, and $[B^2_{dd}]$ and forms $[G_{md}]$ and $[G_{od}]$.

104. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass and damping matrices in modal coordinates:

$$[K_{hh}] = \left[\begin{array}{c|c} k_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][K^2_{dd}][\phi_{dh}] \quad ,$$

$$[M_{hh}] = \left[\begin{array}{c|c} m_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][M^2_{dd}][\phi_{dh}] \quad ,$$

$$[B_{hh}] = \left[\begin{array}{c|c} b_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi^T_{dh}][B^2_{dd}][\phi_{dh}] \quad .$$

where

KDAMP = 1 (default)	KDAMP = -1
m_i = modal masses	m_i = modal masses
$b_i = m_i\ 2\pi\ f_i\ g(f_i)$	$b_i = 0$
$k_i = m_i\ 4\pi^2\ f_i$	$k_i = (1+ig(f_i))\ 4\pi^2\ f_i^2 m_i$

107. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.

110. Go to DMAP No. 119 if no plot output is requested.

112. PLTSET transforms user input into a form used to drive structure plotter.

114. PRTMSG prints error messages associated with structure plotter.

115. Go to DMAP No. 119 if no undeformed aerodynamic or structural element plots are requested.

116. PLØT generates all requested undeformed aerodynamic and structural element plots.

118. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic and structural plot generated.

120. Go to DMAP No. 205 and print error message if no Eigenvalue Extraction Data.

121. GI forms a transformation matrix $[G^T_{ka}]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.

124. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D^1_{jk}]$ and $[D^2_{jk}]$.

127. Go to DMAP No. 129 if no user-supplied downwash coefficients.

128. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D^1_{je}]$m $[D^2_{je}]$). PARAM NØDJE must be set to enter these matrices. The downwash w_j on box j due to the motion of an extra point, u_e, is given by

$$\{w_j\} = [D^1_{je} + ikD^2_{je}]\{u_e\} .$$

131. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \left[\begin{array}{c|c} \phi_{ai} & \phi_{ae} \\ \hline \phi_{ei} & \phi_{ee} \end{array}\right] \qquad [G_{ki}] = [G^T_{ka}]^T[\phi_{ai}]$$

$$[D^1_{jh}] \Leftarrow [D^1_{ji} \mid D^1_{je}] \qquad [D^1_{ji}] = [D^1_{jk}]^T[G_{ki}]$$

$$[D^2_{jh}] \Leftarrow [D^2_{ji} \mid D^2_{je}] \qquad [D^2_{ji}] = [D^2_{jk}]^T[G_{ki}]$$

For each (m,k) pair:

$$[D_{jh}] = [D^1_{jh}] + ik[D^2_{jh}]$$

For each group:

$$[Q_{jh}] = [A^T_{jj}]^{-1}_{\text{group}} [D_{jh}]_{\text{group}}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \left[\begin{array}{c} Q_{ih} \\ \hline Q_{eh} \end{array}\right]$$

137. PARAM initializes the flutter loop counter (FLØØP) to zero.

138. Go to next DMAP instruction if cold start or modified restart. LØØPTØP will be altered by the Executive System to the proper location inside the loop for unmodified restarts within the loop.

139. Beginning of loop for flutter.

140. FA1 computes the total aerodynamic mass matrix $[M^x_{hh}]$, the total aerodynamic stiffness matrix $[K^x_{hh}]$ and the total aerodynamic damping matrix $[B^x_{hh}]$ as well as a looping table FSAVE. For

the K-method

$$M^x_{hh} = (k^2/b^2)M_{hh} + (\rho/2)\,Q_{hh} \;,$$

$$K^x_{hh} = K_{hh} \;,$$

$$B^x_{hh} = 0 \;.$$

145. Go to DMAP No. 149 for KE- and PK-methods.

146. CEAD extracts complex eigenvalues from the equation

$$[M^x_{hh}p^2 + B^x_{hh}p + K^x_{hh}]\{\phi_h\} = 0$$

and normalizes eigenvectors to unit magnitude of largest component.

148. Go to DMAP No. 161 if no complex eigenvalues found.

150. Go to DMAP No. 156 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

151. VDR prepares eigenvectors (ØPHIH) for output, using only the extra points introduced for dynamic analysis and modal coordinates.

153. Go to DMAP No. 156 if no output request for the extra points introduced for dynamic analysis or modal coordinates.

154. ØFP formats tables of eigenvectors for extra points introduced for dynamic analysis and modal coordinates prepared by VDR and places them on the system output file for printing.

157. FA2 appends eigenvectors to PHIHL, eigenvalues to CLAMAL, Case Control to CASEYY, and V-g plot data to ØVG.

160. Go to DMAP No. 165 if there is insufficient time for another flutter loop.

162. Go to DMAP No. 165 if flutter loop complete.

163. Go to DMAP No. 139 for additional aerodynamic configuration triplet values.

168. Go to DMAP No. 173 if no X-Y plot request.

169. XYTRAN prepares the input for requested V-g plotting.

172. XYPLØT prepares requested V-g plots.

175. Go to DMAP No. 211 if no output requests involve dependent degrees of freedom of forces and stresses.

176. MØDACC selects a list of eigenvalues and vectors whose imaginary parts (velocity in input units) are close to a user input list.

177. ADR builds a matrix of aerodynamic forces for each aerodynamic point and prints requested aerodynamic forces for selected elements.

178. DDR1 transforms the complex eigenvectors from modal to physical coordinates

$$\{\phi^c_d\} = \{\phi_{dh}\}\{\phi_h\} \;.$$

180. Equivalence $\{\phi^c_d\}$ to $\{\phi^c_p\}$ if no constraints applied.

181. Go to DMAP No. 183 if no constraints applied.

182. SDR1 recovers dependent components of eigenvectors

$$\{\phi_o^c\} = [G_o^d]\{\phi_d^c\} \quad , \qquad \left\{\begin{array}{c}\phi_d \\ \hline \phi_o\end{array}\right\} = \{\phi_f^c + \phi_e^c\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f^c + \phi_e^c \\ \hline \phi_s^c\end{array}\right\} = \{\phi_n^c + \phi_e^c\} \quad , \qquad \{\phi_m^c\} = [G_m^d]\{\phi_n^c + \phi_e^c\} \quad ,$$

$$\left\{\begin{array}{c}\phi_f^c + \phi_e^c \\ \hline \phi_m^c\end{array}\right\} = \{\phi_p^c\}$$

and recovers single-point forces of constraint $\{q_s\} = [K_{fs}^T]\{\phi_f\}$, $\left\{\begin{array}{c}0 \\ \hline q_s\end{array}\right\} = \{Q_p^c\}$.

185. Equivalence $\{\phi_d^c\}$ to $\{\phi_a^c\}$ if no extra points introduced for dynamic analysis.

186. Go to DMAP No. 189 if no extra points present.

187. VEC generates a d-size partitioning vector (RP) for the a- and e-sets.

$$\{u_d\} \rightarrow \{u_a\} + \{u_e\}$$

188. PARTN performs partition of $\{\phi_d^c\}$ using RP.

$$\{\phi_d^c\} \Rightarrow \left\{\begin{array}{c}\phi_a^c \\ \hline \phi_e^c\end{array}\right\}$$

190. MPYAD recovers the displacements at the aerodynamic points (k).

$$\{\phi_k^c\} = [G_{ka}^T]^T\{\phi_a^c\} \ .$$

191. UMERGE is used to expand $\{\phi_p^c\}$ to the ps-set.

192. UMERGE places $\{\phi_k^c\}$ in its proper place in the displacement vector

$$\{\phi_{pa}^c\} \Leftarrow \left\{\begin{array}{c}\phi_{ps}^c \\ \hline \phi_k^c\end{array}\right\}$$

194. UMERGE is used to expand $\{Q_p^c\}$ to the pa-set.

196. SDR2 calculates element forces (ØEFC1) and stresses (ØESC1) and prepares eigenvectors (ØCPHIPA) and single-point forces of constraint (ØQPAC1) for output and PCPHIPA for deformed plotting.

198. ØFP formats tables prepared by SDR2 and places them on the system output file for printing.

199. Go to DMAP No. 211 if no deformed aerodynamic or structural element plots are requested.

200. PLØT prepares all deformed aerodynamic and structural element plots.

201. PRTMSG prints plotter data and engineering data for each deformed plot generated.

202. Go to DMAP No. 211 and make normal exit.

204. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FORMULATION

206. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 2 - EIGENVALUE EXTRACTION DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

208. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

210. MØDAL CØMPLEX EIGENVALUE ANALYSIS ERRØR MESSAGE NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.20.3 Output for Modal Flutter Analysis

The Real Eigenvalue Summary Table and the Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed. All real eigenvalues are included even though all may not be used in the modal formulation.

The complex eigenvalues are included in the Flutter Summary and are printed for each aerodynamic loop.

The grid point singularities from the structural model are also output.

A Flutter Summary for each value of the configuration parameters is printed out unless PRINT=NØ. This shows Mach number, density, reduced frequency, velocity, damping, and frequency for each complex eigenvalue.

V-g and V-f plots may be requested by the XYØUT control cards by specifying the curve type as VG. The "points" are loop numbers and the "components" are G or F.

Printed output of the following types, sorted by complex eigenvalue root number (SØRT1) and (m, k, ρ) may be requested for all complex eigenvalues kept, as either real and imaginary parts or magnitude and phase angle (0° - 360° lead). (Eigenvectors are not available for the KE-method).

1. The eigenvector for a list of PHYSICAL and AERØDYNAMIC points (grid points, extra points, and aerodynamic points) or SØLUTIØN points (modal coordinates and extra points).
2. Nonzero components of the single-point forces of constraint for a list of PHYSICAL points.
3. Complex stresses and forces in selected elements.

The ØFREQUENCY case control card can select a subset of the complex eigenvectors for data recovery. In addition, undeformed and deformed shapes may be requested. Undeformed shapes may include only structural or structural and aerodynamic elements.

The eigenvectors used in the modal formulation may be obtained for the analysis points by using the ALTER feature to print the matrix of eigenvectors following the execution of READ. The eigenvectors for all points in the model may be obtained by running the problem initially on the Normal Mode Analysis Rigid Format or by making a modified restart using the Normal Mode Analysis Rigid Format.

3.20.4 Case Control Deck and Parameters for Modal Flutter Analysis

1. Only one subcase is allowed.
2. Desired direct input matrices for stiffness $[K^2_{pp}]$, mass $[M^2_{pp}]$, and damping $[B^2_{pp}]$ must be

selected via the keywords K2PP, M2PP, or B2PP.

3. CMETHØD must be used to sele^* an EIGC card from the Bulk Data Deck. (K method only).

4. FMETHØD must be used to select a FLUTTER card from the Bulk Data Deck.

5. METHØD must be used to select an EIGR card that exists in the Bulk Data Deck.

6. SDAMPING must be used to select a TABDMP1 table if structural damping is desired.

The following user parameters are used in Modal Flutter Analysis.

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All flu'd related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. The default vlaues for each parameter is 0.0.

5. LMØDES - required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value is 0.

6. NØDJE - optional in modal flutter analysis. A positive integer of this parameter indicates that user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

7. P1, P2 and P3 - required in modal flutter analysis when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2 and P3 are -1,11 and XXXXXXXX, respectively.

8. VREF - optional in modal flutter analysis. Velocities are divided by the real value of this parameter to convert units or to compute flutter indices. The default value is 1.0.

9. PRINT - optional in modal flutter analysis. The BCD value, NØ, of this parameter will suppress the automatic printing of the flutter summary for the K method. The default value is YES.

10. GUSTAERØ - optional in modal flutter analysis. If gust loads are to be computed (on restart for instance), set value to -1. The default is +1.

11. KDAMP - optional in modal flutter analysis. If set to -1, modal damping is put into a complex stiffness matrix as structural damping (-1 recommended for K and KE methods). The default value is +1.

12. MACH - optional in modal flutter analysis. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default is 0.0.

3.21 MODAL AEROELASTIC RESPONSE

3.21.1 DMAP Sequence for Modal Aeroelastic Response

```
RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

     LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING


OPTIONS IN EFFECT:  GO      ERR=2   NOLIST  NODECK  NOREF   NOOSCAR

    1  BEGIN    AERO NO. 11 MODAL AEROELASTIC RESPONSE SERIES 0 $

    2  FILE     AJJL=APPEND/QHHL=APPEND/QKHL=APPEND/QHJL=APPEND/SKJ=APPEND $

    3  GP1      GEOM1,GEOM2,/GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL/V,N,LUSET/  V,N,
                NOGPDT $

    4  SAVE     LUSET,NOGPDT $

    5  COND     ERROR1,NOGPDT $

    6  GP2      GEOM2,EQEXIN/ECT $

    7  PARAML   PCDB//C,N,PRES/V,Y,NODJE=-1///V,N,JUMPPLOT $

    8  PARAML   XYCDB//C,N,PRES////V,N,NOXYCDB $

    9  PARAM    //C,N,MPY/V,N,NOP/C,N,1/C,N,1 $

   10  PARAM    //C,N,MPY/V,N,NOH/C,N,1/C,N,1 $

   11  GP3      GEOM3,EQEXIN,GEOM2/,GPTT/V,N,NOGRAV $

   12  TA1      ECT,EPT,BGPDT,SIL,GPTT,CSTM/EST,GEI,GPECT,/V,N,LUSET/   V,N,
                NOSIMP/C,N,1/V,N,NOGENL/V,N,GENEL $

   13  SAVE     NOGENL,NOSIMP,GENEL $

   14  COND     ERROR1,NOSIMP $

   15  PARAM    //C,N,ADD/V,N,NOKGGX/C,N,1/C,N,0 $

   16  PARAM    //C,N,ADD/V,N,NOMGG /C,N,1/C,N,0 $

   17  EMG      EST,CSTM,MPT,DIT,GEOM2,/KELM,KDICT,MELM,MDICT,,/V,N,NOKGGX/ V,
                N,NOMGG/C,N,/C,N,/C,N,/C,Y,COUPMASS/C,Y,CPBAR/C,Y,CPROD/  C,Y,
                CPQUAD1/C,Y,CPQUAD2/C,Y,CPTRIA1/C,Y,CPTRIA2/C,Y,CPTUBE/ C,Y,
                CPQDPLT/C,Y,CPTRPLT/C,Y,CPTRBSC $


   18  SAVE     NOKGGX,NOMGG $

   19  COND     JMPKGGX,NOKGGX $

   20  EMA      GPECT,KDICT,KELM/KGGX,GPST $

   21  CHKPNT   KGGX,GPST $

   22  LABEL    JMPKGGX $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
23  COND     ERROR1,NOMGG $

24  EMA      GPECT,MDICT,MELM/MGG,/C,N,-1/C,Y,WTMASS=1.0 $

25  CHKPNT   MGG $

26  COND     LGPWG,GRDPNT $

27  GPWG     BGPDT,CSTM,EQEXIN,MGG/OGPWG/V,Y,GRDPNT=-1/C,Y,WTMASS $

28  OFP      OGPWG,,,,,//V,N,CARDNO $

29  LABEL    LGPWG $

30  EQUIV    KGGX,KGG/NOGENL $

31  CHKPNT   KGG $

32  COND     LBL11,NOGENL $

33  SMA3     GEI,/KGGY/V,N,LUSET/V,N,NOGENL/C,N,-1 $

34  CHKPNT   KGGY $

35  ADD      KGGX,KGGY/KGG $

36  CHKPNT   KGG $

37  LABEL    LBL11 $

38  GP4      CASECC,GEOM4,EQEXIN,GPDT,BGPDT,CSTM/RG,,USET,ASET/V,N,LUSET/V,
             N,MPCF1/V,N,MPCF2/V,N,SINGLE/V,N,OMIT/V,N,REACT/C,N,0/V,N,
             REPEAT/V,N,NOSET/V,N,NOL/V,N,NOA/C,Y,SUBID $

39  SAVE     MPCF1,SINGLE,OMIT,REACT,NOSET,MPCF2, REPEAT,NOL,NOA $

40  CHKPNT   RG,USET $

41  GPSP     GPL,GPST,USET,SIL/OGPST/V,N,NOGPST $


42  SAVE     NOGPST $

43  COND     LBL4,NOGPST $

44  OFP      OGPST,,,,,//V,N,CARDNO $

45  LABEL    LBL4 $

46  EQUIV    KGG,KNN/MPCF1/MGG,MNN/MPCF1 $

47  COND     LBL2,MPCF1 $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
48  MCE1     USET,RG/GM $
49  MCE2     USET,GM,KGG,MGG,,/KNN,MNN,, $
50  CHKPNT   KNN,MNN $
51  LABEL    LBL2 $
52  CHKPNT   GM $
53  EQUIV    KNN,KFF/SINGLE/MNN,MFF/SINGLE $
54  COND     LBL3,SINGLE $
55  SCE1     USET,KNN,MNN,,/KFF,KFS,,MFF,, $
56  LABEL    LBL3 $
57  CHKPNT   KFF,KFS,MFF $
58  EQUIV    KFF,KAA/OMIT/ MFF,MAA/OMIT $
59  CHKPNT   KAA,MAA $
60  PURGE    GO/OMIT $
61  CHKPNT   GO $
62  COND     LBL5,OMIT $
63  PARAM    //C,N,PREC/V,N,PREC $
64  VEC      USET/V/C,N,F/C,N,O/C,N,A $
65  PARTN    KFF,V,/KOO,,KOA,KAAB $
66  CHKPNT   KOO,KOA,KAAB $
67  DECOMP   KOO/LOO,UOO/C,N,1/C,N,0/V,N,MIND/V,N,DET/V,N,NDET/V,N,SING $

68  SAVE     MIND,DET,NDET,SING $
69  COND     LSING,SING $
70  JUMP     CONT1 $
71  LABEL    LSING $
72  PRTPARM  //C,N,0 $
73  LABEL    CONT1 $
```

ORIGINAL PAGE IS
OF POOR QUALITY

PIGID FORMAT DMAP LISTING
SERIES D

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
74  CHKPNT   LOO,UOO $

75  FBS      LOO,UOO,KOA/GO/C,N,1/C,N,-1/V,N,PREC/V,N,PREC $

76  CHKPNT   GO $

77  MPYAD    KOA,GO,KAAB/KAA/C,N,1/C,N,1/C,N,1/V,N,PREC $

78  CHKPNT   KAA $

79  SMP2     USET,GO,MFF/MAA $

80  CHKPNT   MAA $

81  LABEL    LBL5 $

82  COND     LBL6,REACT $

83  RBMG1    USET,KAA,MAA/KLL,KLR,KRR,MLL,MLR,MRR $

84  CHKPNT   KLL,KLR,KRR,MLL,MLR,MRR $

85  RBMG2    KLL/LLL/ $

86  CHKPNT   LLL $

87  RBMG3    LLL,KLR,KRR/DM $

88  CHKPNT   DM $

89  RBMG4    DM,MLL,MLR,MRR/MR $

90  CHKPNT   MR $

91  LABEL    LBL6 $

92  DPD      DYNAMICS,GPL,SIL,USET/GPLD,SILD,USETD,TFPOOL,DLT,PSDL,FRL,,TRL,
             EED,EQDYN/V,N,LUSET/V,N,LUSETD/V,N,NOTFL/V,N,NODLT/V,N,NOPSDL/
             V,N,NOFRL/V,N,NONLFT/V,N,NOTRL/V,N,NOEED/C,N,123/V,N,NOUE $


93  SAVE     LUSETD,NOUE,NOEED,NOPSDL $

94  COND     ERROR2,NOEED $

95  EQUIV    GO,GOD/NOUE/GM,GMD/NOUE $

96  READ     KAA,MAA,MR,DM,EED,USET,CASECC/LAMA,PHIA,MI,OEIGS/C,N,MODES/V,N,
             NEIGV $

97  SAVE     NEIGV $

98  CHKPNT   LAMA,PHIA,MI,OEIGS $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
 99  OFP      OEIGS,LAMA,,,,//V,N,CARDNO $

100  COND     ERROR4,NEIGV $

101  MTRXIN   CASECC,MATPOOL,EQDYN,,TFPOOL/K2PP,M2PP,B2PP/V,N,LUSETD/V,N,
              NOK2PP/V,N,NOM2PP/V,N,NOB2PP $

102  SAVE     NOK2PP,NOM2PP,NOB2PP $

103  EQUIV    M2PP,M2DD/NOA/B2PP,B2DD/NOA/K2PP,K2DD/NOA $

104  CHKPNT   K2PP,M2PP,B2PP,K2DD,M2DD,B2DD $

105  GKAD     USETD,GM,GO,,,,,K2PP,M2PP,B2PP/,,,GMD,GOD,K2DD,M2DD,B2DD/C,N,
              CMPLEV/C,N,DISP/C,N,MODAL/C,N,0.0/C,N,0.0/C,N,0.0/V,N,NOK2PP/V,
              N,NOM2PP/V,N,NOB2PP/ V,N,MPCF1/V,N,SINGLE/V,N,OMIT/V,N,NOUE/C,
              N,-1/C,N,-1/ C,N,-1/C,N,-1 $

106  CHKPNT   K2DD,M2DD,B2DD,GOD,GMD $

107  GKAM     USETD,PHIA,,LAMA,DIT,M2DD,B2DD,K2DD,CASECC/MHH,BHH,KHH,PHIDH/V,
              N,NOUE/C,Y,LMODES=0/C,Y,LFREQ=0./C,Y,HFREQ=0./V,N,  NOM2PP/V,N,
              NOB2PP/V,N,NOK2PP/V,N,NONCUP/V,N,FMODE/C,Y,KDAMP $

108  SAVE     NONCUP,FMODE $

109  CHKPNT   MHH,BHH,KHH,PHIDH $

110  APD      EDT,EQDYN,ECT,BGPDT,SILD,USETD,CSTM,GPLD/EQAERO,ECTA,BGPA,SILA,
              USETA,SPLINE,AERO,ACPT,FLIST,CSTMA,GPLA,SILGA/V,N,NK/V,N,NJ/V,
              N,LUSETA/V,N,BOV $

111  SAVE     NK,NJ,LUSETA,BOV $

112  PARAM    //C,N,MPY/V,N,PFILE/C,N,0/C,N,1 $

113  COND     SKPPLT,JUMPPLOT $

114  PARAM    //C,N,MPY/V,N,PLTFLG/C,N,0/C,N,1 $


115  PLTSET   PCDB,EQAERO,ECTA/PLTSETA,PLTPARA,GPSETSA,ELSETSA/V,N,NSIL1/V,N,
              JUMPPLOT $

116  SAVE     NSIL1,JUMPPLOT $

117  PRTMSG   PLTSETA // $

118  COND     SKPPLT,JUMPPLOT $

119  PLOT     PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO, ,,,,/PLOTX2/V,N,
              NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
120  SAVE     PFILE,JUMPPLOT,PLTFLG $
121  PRTMSG   PLOTX2 // $
122  LABEL    SKPPLT $
123  GI       SPLINE,USET ,CSTMA,BGPA,SIL , ,GM,GO/GTKA/V,N,NK/V,N,LUSET $
124  CHKPNT   GTKA $
125  PARAM    //C,N,ADD/V,N,DESTRY/C,N,0/C,N,1/ $
126  AMG      AERO,ACPT/AJJL,SKJ,D1JK,D2JK/V,N,NK/V,N,NJ/V,N,DESTRY/ $
127  SAVE     DESTRY $
128  CHKPNT   AJJL,SKJ,D1JK,D2JK $
129  COND     NODJE,NODJE $
130  INPUTT2  /D1JE,D2JE,,,/C,Y,P1=-1/C,Y,P2=11/C,Y,P3=TAPEID $
131  LABEL    NODJE $
132  PARAM    //C,N,ADD/V,N,XQHHL/C,N,1/C,N,0 $
133  AMP      AJJL,SKJ,D1JK,D2JK,GTKA,PHIDH,D1JE,D2JE,USETD,AERO/QHHL,QKHL,
              QHJL/V,N,NOUE/V,N,XQHHL/V,Y,GUSTAERO=+1 $
134  SAVE     XQHHL $
135  CHKPNT   QHHL,QHJL,QKHL $
136  FRLG     CASECC,USETD,DLT,FRL,GMD,GOD,DIT,PHIDH/PPF,PSF,PDF,FOL,PHF1/
              C,N,MODAL/V,N,FREQY/V,N,APP $
137  SAVE     FREQY,APP $
136  CHKPNT   PPF,PSF,PDF,FOL,PHF1 $

139  PARAM    //C,N,NOT/V,N,NOFRY/V,N,FREQY $
140  PURGE    PPF/NOFRY $
141  CHKPNT   PPF $
142  GUST     CASECC,DLT,FRL,DIT,QHJL,,,ACPT,CSTMA,PHF1/PHF/ V,N,NOGUST/V,N,
              BOV/C,Y,MACH/C,Y,Q $
143  SAVE     NOGUST $
144  EQUIV    PHF1,PHF/NOGUST $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
145  CHKPNT    PHF $
146  FRRD2     KHH,BHH,MHH,QHHL,PHF,FOL/UHVF/V,N,BOV/C,Y,Q/C,Y,MACH $
147  CHKPNT    UHVF $
148  EQUIV     UHVF,UHVT/FREQY/FOL,TOL/FREQY $
149  CHKPNT    UHVT,TOL $
150  COND      IFTSKP,FREQY $
151  IFT       UHVF,CASECC,TRL,FOL/UHVT,TOL/C,Y,IFTM=0 $
152  CHKPNT    UHVT,TOL $
153  LABEL     IFTSKP $
154  MODACC    CASECC,TOL,UHVT,,,/TOL1,UHVT1,,,/V,N,APP $
155  ADR       UHVT1,CASECC,QKHL,TOL1,SPLINE,SILA,USETA/PKF/V,N,BOV/   C,Y,
               MACH/V,N,APP $
156  VDR       CASECC,EQDYN,USETD,UHVT1,TOL1,XYCDB,/OUHV1,/V,N,APP/C,N,MODAL/
               C,N,0/V,N,NOH/V,N,NOP/V,N,FMODE $
157  SAVE      NOH,NOP $
158  COND      NOH,NOH $
159  SDR3      OUHV1,,,,,/OUHV2,,,,, $
160  OFP       OUHV2,,,,,//V,N,CARDNO $
161  SAVE      CARDNO $
162  COND      NOH,NOXYCDB $
163  XYTRAN    XYCDB,OUHV2,,,,/XYPTTA/V,N,APP/C,N,HSET/V,N,PFILE/V,N,CARDNO/V,
               N,NOXYPL $

164  SAVE      PFILE,CARDNO,NOXYPL $
165  COND      NOH,NOXYPL $
166  XYPLOT    XYPTTA $
167  LABEL     NOH $
168  PARAM     //C,N,AND/V,N,PJUMP/V,N,NOP/V,N,JUMPPLOT $
169  COND      FINIS,PJUMP $
```

RIGID FORMAT DMAP LISTING
SERIES O

AERO APPROACH, RIGID FORMAT 11

```
    LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

170  SDR1     USETD,,PHIDH,,,GOD,GMD,,KFS,,/PHIP,,QP/C,N,1/C,N,DYNAMICS $
171  EQUIV    PHIDH,PHIAH/NOUE $
172  COND     NOUE1,NOUE $
173  VEC      USETD/EVEC/C,N,D/C,N,A/C,N,E $
174  PARTN    PHIDH,,EVEC/PHIAH,,,/C,N,1 $
175  LABEL    NOUE1 $
176  MPYAD    GTKA,PHIAH,/PHIK/C,N,1/C,N,1/C,N,0/V,N,PREC $
177  UMERGE   USETA,PHIP,/PHIPS/C,N,PS/C,N,P/C,N,SA $
178  UMERGE   USETA,PHIPS,PHIK/PHIPA/C,N,PA/C,N,PS/C,N,K $
179  CHKPNT   PHIPA $
180  UMERGE   USETA,QP,/QPA/C,N,PA/C,N,P/C,N,PS $
181  CHKPNT   QPA $
182  SDR2     CASECC,CSTMA,MPT,DIT,EQAERO,SILA,,,BGPA,LAMA,QPA,PHIPA,EST,
              XYCDB,/ ,MQP1,MPHIPA1,MES1,MEF1,/C,N,MMREIG $
183  COND     NOPF,NOFRY $
184  SDR2     CASECC,,,,EQDYN,,,,,PPF,,,,XYCDB,/OPP1,,,,,,/C,N,FREQ $
185  SDR3     OPP1,,,,,/OPP2,,,,,,/ $
186  LABEL    NOPF $
187  SDR3     MPHIPA1,MES1,MEF1,MQP1,,/MPHIPA2,MES2,MEF2,MQP2,, $
188  DDRMM    CASECC,UHVT1,TOL1,MPHIPA2,MQP2,MES2,MEF2,XYCDB,EST,MPT,DIT/
              OUPV2,OQP2,OES2,OEF2, $

189  OFP      OUPV2,,OES2,OEF2,OQP2,//V,N,CARDNO $
190  SAVE     CARDNO $
191  COND     P2,JUMPPLOT $
192  MPYAD    PHIPA,UHVT1,/UVT1/C,N,0 $
193  SDR2     CASECC,CSTMA,,,EQAERO,,,,BGPA,TOL,,UVT1,,,/,,,,,PUVPAT/APP $
194  PLOT     PLTPARA,GPSETSA,ELSETSA,CASECC,BGPA,EQAERO,SILGA,,PUVPAT,,/
              PLOTX3/V,N,NSIL1/V,N,LUSETA/V,N,JUMPPLOT/V,N,PLTFLG/V,N,PFILE $
```

RIGID FORMAT DMAP LISTING
SERIES 0

AERO APPROACH, RIGID FORMAT 11

LEVEL 2.0 NASTRAN DMAP COMPILER - SOURCE LISTING

```
195  PRTMSG   PLOTX3// $

196  LABEL    P2 $

197  COND     FINIS,NOXYCDB $

198  XYTRAN   XYCDB,,OQP2,OUPV2,OES2,OEF2/XYPLTT/V,N,APP/C,N,PSET/ V,N,PFILE/
              V,N,CARDNO/V,N,NOXYPL $

199  SAVE     PFILE,CARDNO,NOXYPL $

200  COND     NOXYPLTT,NOXYPL $

201  XYPLOT   XYPLTT $

202  LABEL    NOXYPLTT $

203  COND     FINIS,NOFRY $

204  COND     FINIS,NOPSDL $

205  RANDOM   XYCDB,DIT,PSDL,OUPV2,,OQP2,OES2,OEF2,CASECC/PSDF,AUTO/   V,N,
              NORN $

206  SAVE     NORN $

207  COND     FINIS,NORN $

208  XYTRAN   XYCDB,PSDF,AUTO,,,/XYPLTR/C,N,RAND/C,N,PSET/V,N,PFILE/   V,N,
              CARDNO/V,N,NOXYPL $

209  SAVE     PFILE,CARDNO,NOXYPL $

210  COND     FINIS,NOXYPL $

211  XYPLOT   XYPLTR $

212  JUMP     FINIS $

213  LABEL    ERROR2 $


214  PRTPARM  //C,N,-2/C,N,AERORESP $

215  LABEL    ERROR1 $

216  PRTPARM  //C,N,-1/C,N,AERORESP $

217  LABEL    ERROR4 $

218  PRTPARM  //C,N,-4/C,N,AERORESP $

219  LABEL    FINIS $

220  END      $
```

3.21.2 Description of DMAP Operations for Aeroelastic Response

3. GP1 generates coordinate system transformation matrices, tables of grid point locations, and tables to relate internal to external grid point numbers.

5. Go to DMAP No. 215 and print error message if no grid points are present.

6. GP2 generates Element Connection Table with internal indices.

11. GP3 generates Grid Point Temperature Table (element temperature).

12. TA1 generates element tables for use in matrix assembly and stress recovery.

14. Go to DMAP No. 215 and print error message if no elements have been defined.

17. EMG generates structural element stiffness and mass matrix tables and dictionaries for later assembly.

19. Go to DMAP No. 22 if no stiffness matrix is to be assembled.

20. EMA assembles stiffness matrix $[K^x_{gg}]$ and Grid Point Singularity Table.

23. Go to DMAP No. 215 and print error message if no mass matrix exists.

24. EMA assembles mass matrix $[M_{gg}]$.

26. Go to DMAP No. 29 if no weight and balance request.

27. GPWG generates weight and balance information.

28. ØFP formats weight and balance information prepared by GPWG and places it on the system output file for printing.

30. Equivalence $[K^x_{gg}]$ to $[K_{gg}]$ if no general elements.

32. Go to DMAP No. 37 if no general elements.

33. SMA3 forms the general element stiffness matrix $[K^y_{gg}]$.

35. ADD combines the structural stiffness matrix $[K^x_{gg}]$ with the general element stiffness matrix $[K^y_{gg}]$ to obtain the stiffness matrix $[K_{gg}$.

38. GP4 generates flags defining members of various displacement sets (USET) and forms multipoint constraint equations $[R_g]\{u_g\} = 0$.

41. GPSP determines if possible grid point singularities remain.

43. Go to DMAP No. 45 if no grid point singularities remain.

44. ØFP formats table of possible grid point singularities prepared by GPSP and places it on the system output file for printing.

46. Equivalence $[K_{gg}]$ to $[K_{nn}]$ and $[M_{gg}]$ to $[M_{nn}]$ if no multipoint constraints.

47. Go to DMAP No. 51 if MCE1 and MCE2 have already been executed for the current set of multipoint constraints.

48. MCE1 partitions multipoint constraint equations $[R_g] = [R_m \mid R_n]$ and solves for multipoint constraint transformation matrix $[G_m] = -[R_m]^{-1}[R_n]$.

49. MCE2 partitions stiffness and mass matrices

$$[K_{gg}] = \left[\begin{array}{c|c} \bar{K}_{nn} & K_{nm} \\ \hline K_{mn} & K_{mm} \end{array}\right] \quad \text{and} \quad [M_{gg}] = \left[\begin{array}{c|c} \bar{M}_{nn} & M_{nm} \\ \hline M_{mn} & M_{mm} \end{array}\right]$$

and performs matrix reductions

$$[K_{nn}] = [\bar{K}_{nn}] + [G_m^T][K_{mn}] + [K_{mn}^T][G_m] + [G_m^T][K_{mm}][G_m], \text{ and}$$

$$[M_{nn}] = [\bar{M}_{nn}] + [G_m^T][M_{mn}] + [M_{mn}^T][G_m] + [G_m^T][M_{mm}][G_m] .$$

53. Equivalence $[K_{nn}]$ to $[K_{ff}]$ and $[M_{nn}]$ to $[M_{ff}]$ if no single-point constraints.

54. Go to DMAP No. 56 if no single-point constraints.

55. SCE1 partitions out single-point constraints

$$[K_{nn}] = \left[\begin{array}{c|c} K_{ff} & K_{fs} \\ \hline K_{sf} & K_{ss} \end{array}\right] \quad \text{and} \quad [M_{nn}] = \left[\begin{array}{c|c} M_{ff} & M_{fs} \\ \hline M_{sf} & M_{ss} \end{array}\right]$$

58. Equivalence $[K_{ff}]$ to $[\bar{K}_{aa}]$ and $[M_{ff}]$ to $[M_{aa}]$ if no omitted degrees of freedom.

62. Go to DMAP No. 81 if no omitted coordinates.

64. VEC generates an f-size partitioning vector (V) for the o- and a-sets

$$\{u_f\} \rightarrow \{u_o\} + \{u_a\}$$

65. PARTN partitions constrained stiffness matrix using V.

$$[K_{ff}] = \left[\begin{array}{c|c} \bar{K}_{aa} & K_{ao} \\ \hline K_{oa} & K_{oo} \end{array}\right]$$

67. DECØMP decomposes $[K_{oo}]$ into lower and upper triangular factors $[L_{oo}]$ and $[U_{oo}]$.

69. Go to DMAP No. 71 if $[K_{oo}]$ is singular.

70. Go to DMAP No. 73 if $[K_{oo}]$ is not singular.

72. PRTPARM prints all parameters when $[K_{oo}]$ is singular.

75. FBS solves for the transformation matrix $[G_o] = -[K_{oo}]^{-1}[K_{oa}]$.

77. MPYAD performs matrix reduction $[K_{aa}] = [\bar{K}_{aa}] + [K_{oa}^T][G_o]$.

79. SMP2 partitions constrained stiffness matrix

$$[M_{ff}] = \left[\begin{array}{c|c} \bar{M}_{aa} & M_{ao} \\ \hline M_{oa} & M_{oo} \end{array}\right]$$

and performs matrix reduction

$$[M_{aa}] = [\bar{M}_{aa}] + [M_{oa}^T][G_o] + [G_o^T][M_{oo}][G_o] + [G_o^T][M_{oa}].$$

82. Go to DMAP No. 91 if no free-body supports.

83. RBMG1 partitions out free-body supports

$$[K_{aa}] = \left[\begin{array}{c|c} K_{\ell\ell} & K_{\ell r} \\ \hline K_{r\ell} & K_{rr} \end{array}\right] \text{ and } [M_{aa}] = \left[\begin{array}{c|c} M_{\ell\ell} & M_{\ell r} \\ \hline M_{r\ell} & M_{rr} \end{array}\right]$$

85. RBMG2 decomposes constrained stiffness matrix $[K_{\ell\ell}] = [L_{\ell\ell}][U_{\ell\ell}]$.

87. RBMG3 forms rigid body transformation matrix

$$[D] = -[K_{\ell\ell}]^{-1}[K_{\ell r}]$$

calculates rigid body check matrix

$$[X] = [K_{rr}] + [K_{\ell r}^T][D] ,$$

and calculates and outputs rigid body error ratio

$$\varepsilon = \frac{||X||}{||K_{rr}||}$$

89. RBMG4 forms rigid body mass matrix $[m_r] = [M_{rr}] + [M_{\ell r}^T][D] + [D^T][M_{\ell r}] + [D^T][M_{\ell\ell}][D]$.

92. DPD generates flags defining members of various displacement sets used in dynamic analysis (USETD), tables relating internal to external grid point numbers, including extra points introduced for dynamic analysis, and prepares Transfer Function Pool and Eigenvalue Extraction Data.

94. Go to DMAP No. 213 and print error message if no Eigenvalue Extraction Data.

95. Equivalence $[G_o]$ to $[G_o^d]$ and $[G_m]$ to $[G_m^d]$ if no extra points introduced for dynamic analysis.

96. READ extracts real eigenvalues and vectors from the equation

$$[K_{aa} - \lambda M_{aa}]\{\phi_a\} = 0 ,$$

calculates rigid body modes by finding a matrix $[\phi_{ro}]$ such that

$$[m_o] = [\phi_{ro}^T][m_r][\phi_{ro}]$$

is diagonal and normalized and computes rigid body eigenvectors

$$[\phi_{ao}] = \begin{bmatrix} D\,\phi_{ro} \\ \hline \phi_{ro} \end{bmatrix} ,$$

and calculates modal mass matrix

$$[m] = [\phi_a^T][M_{aa}][\phi_a]$$

and normalizes eigenvectors according to one of the following user requests:

1) Unit value of selected coordinate
2) Unit value of largest component
3) Unit value of generalized mass

99. ØFP formats the summary of eigenvalues (LAMA) and the summary of eigenvalue extraction information (ØEIGS) prepared by READ and places them on the system output file for printing.

100. Go to DMAP No. 217 and print error message if no eigenvalues found.

101. MTRXIN selects the direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[B_{pp}^2]$.

103. Equivalence $[M_{pp}^2]$ to $[M_{dd}^2]$, $[B_{pp}^2]$ to $[B_{dd}^2]$, and $[K_{pp}^2]$ to $[K_{dd}^2]$ if no constraints applied.

105. GKAD applies constraints to direct input matrices $[K_{pp}^2]$, $[M_{pp}^2]$, and $[B_{pp}^2]$, forming $[K_{dd}^2]$, $[M_{dd}^2]$, and $[B_{dd}^2]$ and forms $[G_{md}]$ and $[G_{od}]$.

107. GKAM selects eigenvectors to form $[\phi_{dh}]$ and assembles stiffness, mass, and damping matrices in modal coordinates.

$$[K_{hh}] = \left[\begin{array}{c|c} k_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi_{dh}^T][K_{dd}^2][\phi_{dh}] ,$$

$$[M_{hh}] = \left[\begin{array}{c|c} m_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi_{dh}^T][M_{dd}^2][\phi_{dh}] ,$$

$$[B_{hh}] = \left[\begin{array}{c|c} b_i & 0 \\ \hline 0 & 0 \end{array}\right] + [\phi_{dh}^T][B_{dd}^2][\phi_{dh}] ,$$

where

KDAMP = 1 (default)	KDAMP = -1
m_i = modal masses	m_i = modal masses
$b_i = m_i\, 2\pi\, f_i\, g(f_i)$	$b_i = 0$
$k_i = m_i\, 4\pi^2 f_i^2$	$k_i = (1+ig(f_i))\, 4\pi^2 f_i^2\, m_i$

110. APD processes the aerodynamic data cards from EDT. It adds the k points and the SA points to USETD making USETA. EQAERØ, ECTA, BGPA, CSTMA, GPLA, and SILA are updated to reflect the new elements. AERØ and ACPT reflect the aerodynamic parameters. SILGA is a special SIL for plotting.

113. Go to DMAP No. 122 if no plot output is requested.

115. PLTSET transforms user input into a form used to drive structure plotter.

117. PRTMSG prints error messages associated with structure plotter.

118. Go to DMAP No. 122 if no undeformed aerodynamic or structural element plots are requested.

119. PLØT generates all requested undeformed aerodynamic and structural element plots.

121. PRTMSG prints plotter data and engineering data for each undeformed aerodynamic and structural element plot generated.

123. GI forms a transformation matrix $[G^T_{ka}]$ which interpolates between aerodynamic (k) and structural (a) degrees of freedom.

126. AMG forms the aerodynamic matrix list $[A_{jj}]$, the area matrix $[S_{kj}]$, and the downwash coefficients $[D^1_{jk}]$ and $[D^2_{jk}]$.

129. Go to DMAP No. 131 if no user-supplied downwash coefficients.

130. INPUTT2 provides the user-supplied downwash factors due to extra points ($[D^1_{je}]$, $[D^2_{je}]$). PARAM NØDJE must be set to enter these matrices. The downwash w_j on box j due to the motion of an extra point, u_e, is given by $\{w_j\} = [D^1_{je} + ik\, D^2_{je}]\{u_e\}$.

133. AMP computes the aerodynamic matrix list related to the modal coordinates as follows:

$$[\phi_{dh}] = \left[\begin{array}{c:c} \phi_{ai} & \phi_{ae} \\ \hdashline \phi_{ei} & \phi_{ee} \end{array}\right]$$

$$[G_{ki}] = [G^T_{ka}]^T[\ _{ai}]$$

$$[D^1_{ji}] = [D^1_{jk}]^T[G_{ki}]$$

$$[D^2_{ji}] = [D^2_{jk}]^T[G_{ki}]$$

$$[D^1_{jh}] \Leftarrow [D^1_{ji} \mid D^1_{je}]$$

$$[D^2_{jh}] \Leftarrow [D^2_{ji} \mid D^2_{je}]$$

For each (m,k) pair:

$$[D_{jh}] = [D^1_{hg}] + ik[D^2_{jh}]$$

for each group:

$$[Q_{jh}] = [A^T_{jj}]^{-1}_{group}[D_{jh}]_{group}$$

$$[Q_{kh}] = [S_{kj}][Q_{jh}]$$

$$[Q_{ih}] = [G_{ki}]^T[Q_{kh}]$$

$$[Q_{hh}] \Leftarrow \left[\frac{Q_{ih}}{Q_{eh}=0}\right]$$

136. FRLG forms the dynamic load vector $\{P_h\}$ from the frequency response data or transient data using a Fourier Transform.

142. GUST forms the loading due to gusts and adds to the direct loads.

144. Equivalence {PHF1} to {PHF} if no gust loads.

146. FRRD2 solves for the modal displacements using

$$[-M_{hh}\omega^2 + iB_{hh}\omega + K + qQ_{hh}(k)]U_h = P_h(\omega) .$$

148. Equivalence {UHVF} to {UHVT} and FØL to TØL if frequency response formulation.

150. Go to DMAP No. 153 if frequency response formulation.

151. IFT does in Inverse Fourier Transform of the displacements for transient formulation.

154. MØDACC uses data from ØFREQ or ØTIME data cards to select solutions for data recovery.

155. ADR produces aerodynamic load output (PKF) for selected points in frequency response only.

156. VDR prepares solution set displacements (ØUHV1), sorted by frequency or time, for output. The solution set includes mode amplitudes and extra points.

158. Go to DMAP No. 167 if output sorted by frequency or time step.

159. SDR3 prepares requested output sorted by solution set points.

160. ØFP formats tables prepared by SDR3 for output sorted by solution set point.

162. Go to DMAP No. 167 if no X-Y plots requested.

163. XYTRAN prepares the input for X-Y plotting of solution set points versus time or frequency.

165. Go to DMAP No. 167 if no plots possible as requested.

169. Go to DMAP No. 219 if no output for physical points requested.

170. SDR1 recovers physical displacements (PHIP) and forces of constraint (QP) for the real eigenvectors associated with the modes.

171. Equivalence $\{\phi_{dh}\}$ to $\{\phi_{ah}\}$ if no extra points introduced for dynamic analysis.

172. Go to DMAP No. 175 if no extra points present.

173. VEC generates a d-size partitioning vector (EVEC) for the a- and e-sets

$$\{u_d\} \rightarrow \{u_a\} + \{u_e\}$$

174. PARTN performs partition of $\{\phi_{dh}\}$ using EVEC.

$$\{\phi_{dh}\} \Rightarrow \left\{\begin{array}{c}\phi_{ah} \\ \hline 0\end{array}\right\}$$

176. MPYAD recovers displacements at the aerodynamic points (k).

$$\{\phi_k\} = [G^T_{ka}]^T\{\phi_{ah}\}$$

177. UMERGE is used to expand $\{\phi_p\}$ to the ps-set.

178. UMERGE places $\{\phi_k\}$ in its proper place in the displacement vector

$$\{\phi_{pa}\} \Leftarrow \left\{\begin{array}{c}\phi_{ps} \\ \hline \phi_k\end{array}\right\}$$

180. UMERGE is used to expand $\{Q_p\}$ to the pa-set.

182. SDR2 calculates element forces (MEF1) and stresses (MES1) and prepares eigenvectors (MPHIPA1) and single-point forces of constraint (MQP1) for output sorted by frequency or time.

183. Go to DMAP No. 186 if not frequency response.

184. SDR2 prepares load vectors for output (ØPP1) sorted by frequency.

185. SDR3 prepares requested load output sorted by point number.

187. SDR3 prepares requested modal quantities output sorted by point number.

188. DDRMM prepares a subset of the element forces (ØEF2) amd stresses (ØES2), displacement vectors (ØUPV2), and single-point forces of constraint (ØQP2) solutions for output sorted by point number or element number.

189. ØFP formats requested physical output prepared by DDRMM and places it on the system output file for printing.

191. Go to DMAP No. 196 if no deformed aerodynamic or structural element plots requested.

193. SDR2 prepares vectors for deformed plotting.

194. PLØT prepares all requested deformed aerodynamic and structural element plots.

195. PRTMSG prints plotter data and engineering data for each deformed plot generated.

197. Go to DMAP No. 219 if no X-Y plots requested.

198. XYTRAN prepares the input for physical point X-Y plots.

200. Go to DMAP No. 202 if no plots possible as requested.

201. XYPLØT prepares requested X-Y plots of displacements, forces, stresses, loads, or single-point forces of constraint versus frequency or time.

203. Go to DMAP No. 219 if transient response.

204. Go to DMAP No. 219 if no power spectral density functions or autocorrelation functions requested.

205. RANDØM calculates power spectral density functions (PSDF) and autocorrelation functions (AUTØ) using the previously calculated frequency response.

207. Go to DMAP No. 219 if no X-Y plots of RANDØM Calculations requested.

208. XYTRAN prepares the input for requested X-Y plots of the RANDØM output.

210. Go to DMAP No. 219 if no plots possible as requested.

211. XYPLØT prepares requested X-Y plots of autocorrelation functions and power spectral density functions.

212. Go to DMAP No. 219 and make normal exit.

214. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

216. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

218. MØDAL AERØELASTIC RESPØNSE ERRØR NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

3.21.3 Case Control Deck and Parameters for Aeroelastic Response Analysis

The following items relate to subcase definition and data selection for Modal Aeroelastic Response:

1. METHØD must appear above the subcase level to select eigenvalue extraction method.

2. At least one subcase must be defined for each unique set of direct input matrices (K2PP, M2PP, B2PP) or frequencies.

3. Consecutive subcases for each set of direct input matrices or frequencies are used to define the loading condition - one subcase for each dynamic loading condition.

4. Constraints must be defined above the subcase level.

5. DLØAD must be used to define a frequency-dependent loading condition for each subcase. If transient loads are selected, a Fourier Transform is used to compute frequency-dependent loads. All loads in one run must be of the same type.

6. FREQUENCY must be used to select one, and only one, FREQ, FREQ1, or FREQ2 card from the Bulk Data Deck. If TLØADs are selected, a TSTEP must be selected.

7. ØFREQUENCY (ØTIME) may be used above the subcase level or within each subcase to select a subset of the solution frequencies (times) for output requests. The default is to use all solution frequencies (times).

8. If Random Response calculations are desired, RANDØM must be used to select RANDPS and RANDTi cards from the Bulk Data Deck. Only one ØFREQUENCY and FREQUENCY card can be used for each set of direct input matrices.

The Real Eigenvalue Summary Table and Real Eigenvalue Analysis Summary, as described under Normal Mode Analysis, are automatically printed.

The following printed output, sorted by point number or element number (SØRT2), is available, either as real and imaginary parts or magnitude and phase angle (0° - 360° lead), for the list of frequencies specified by ØFREQUENCY (in transient formulations, these are real):

1. Displacements, velocities, and accelerations for a list of PHYSICAL points (grid points and extra scalar points introduced for dynamic analysis) or SØLUTIØN points (points used in formulation of the general K system). Velocities and accelerations are not available for transient analysis.

2. Nonzero components of the applied load vector and single-point forces of constraint for a list of PHYSICAL points. Aerodynamic forces on selected aerodynamic elements.

3. Stress and forces in selected elements (ALL available only for SØRT1).

The following printed output is available for Random Response calculations:

1. Power spectral density function and mean deviation for the response of selected components for points or elements. The expected frequency of zero crossings.

2. Autocorrelation function for the response of selected components for points or elements.

The following plotter output is available:

1. Undeformed plot of the structural model.

2. Deformed shapes of the aerodynamic and structural model for selected intervals.

3. X-Y plot of any component of displacement, velocity, or acceleration of a PHYSICAL point or SØLUTIØN point.

4. X-Y plot of any component of the applied load vector or single-point force of constraint.

5. X-Y plot of any stress or force component for an element.

The following plotter output is available for Random Response calculations:

1. X-Y plot of the power spectral density versus frequency for the response of selected components for points or elements.

2. X-Y plot of the autocorrelation versus time lag for the response of selected components for points or elements.

The data used for preparing the X-Y plots may be punched or printed in tabular form (see Section 4.2). Also, a printed summary is prepared for each X-Y plot which includes the maximum and minimum values of the plotted function.

The following parameters are used in Aeroelastic Response calculations:

1. GRDPNT - optional - A positive integer value of this parameter will cause the Grid Point Weight Generator to be executed and the resulting weight and balance information to be printed. All fluid related masses are ignored.

2. WTMASS - optional - The terms of the structural mass matrix are multiplied by the real value of this parameter when they are generated in EMA. Not recommended for use in hydroelastic problems.

3. CØUPMASS - CPBAR, CPRØD, CPQUAD1, CPQUAD2, CPTRIA1, CPTRIA2, CPTUBE, CPQDPLT, CPTRPLT, CPTRBSC - optional - These parameters will cause the generation of coupled mass matrices rather than lumped mass matrices for all bar elements, rod elements, and plate elements that include bending stiffness.

4. LFREQ and HFREQ - Required unless LMØDES is used. The real values of these parameters give the frequency range (LFREQ is lower limit and HFREQ is upper limit) of the modes to be used in the modal formulation. The default value for each parameter is 0.0.

5. LMØDES - Required unless LFREQ and HFREQ are used. The integer value of this parameter is the number of lowest modes to be used in the modal formulation. The default value is 0.

6. KDAMP - optional in aeroelastic response. If set to -1, modal damping is put into a complex stiffness matrix as structural damping. The default value is +1.

7. GUSTAERØ - optional in aeroelastic response. An integer value of -1 causes gust loads to be computed. The default value is +1.

8. IFTM - optional in aeroelastic response. The value of this parameter selects the method for the integration of the Inverse Fourier Transform. The integer 0 specifies a rectangular fit; 1 specifies a trapezoidal fit; and 2 specifies a cubic spline fit. The default value is 0.

9. MACH - optional in aeroelastic response. The real value of this parameter selects the closest Mach numbers to be used to compute aerodynamic matrices. The default value is 0.0.

10. Q - Real, required in aeroelastic response. The real value of this parameter defines the dynamic pressure.

11. NØDJE - optional in aeroelastic response. A positive integer for this parameter indicates user supplied downwash matrices due to extra points are to be read from tape via the INPUTT2 module in the rigid format. The default value is -1.

12. <u>P1, P2, and P3</u> - required in aeroelastic response when using NØDJE parameter. See Section 5.3.2 for tape operation parameters required by INPUTT2 module. The defaults for P1, P2, and P3, as defined in the rigid format, are -1, 11, and TAPEID, respectively.

4. PLOTTING

4.1 PLOTTING

NASTRAN provides the capability for generating on any of several different plotters the following kinds of plots:

1. Undeformed geometric projections of the structural model.

2. Static deformations of the structural model by either displaying the deformed shape (alone or superimposed on the undeformed shape), or displaying the displacement vectors at the grid points (superimposed on either the deformed or undeformed shape).

3. Modal deformations (sometimes called mode shapes or eigenvectors) resulting from real eigenvalue analysis by the same options stated in 2 above. Complex modes of flutter analysis may be plotted for any user chosen phase lag.

4. Deformations of the structural model for transient response or frequency response by displaying either vectors or the deformed shape for specified times or frequencies.

5. X-Y graphs of transient response (time), frequency response (frequency), or static response (subcase).

6. V-f and V-g graphs of flutter analysis.

7. Topological displays of matrices.

8. Contour plots of stress and displacement. To avoid crowded output an outline of the model may be optionally requested.

Structure plots (items 1-4) are discussed in Section 4.2 while X-Y plots (item 5) are discussed in Section 4.3. Matrix plots are generated by Utility Module SEEMAT described in Section 5 and must be accomplished by altering a Rigid Format or using a DMAP sequence. Requests for structure plots or X-Y plots are accomplished in the Case Control Deck by sumbitting a structure plot request packet or an X-Y output request packet. The discussion of these packets constitutes most of the remainder of this chapter. The optional PLØTID card is considered to be part of the plot packets, although it must precede any ØUTPUT(PLØT), ØUTPUT(XYØUT), or ØUTPUT(XYPLØT) cards (See the PLØTID card in Section 2.3).

In order to actually create plots, a plotter and model name must be specified by the user. The method used to specify this information may vary according to the plot request made, but the actual names used do not vary. In addition, a physical plot tape or mass storage area must be set up by the user. The system control cards needed to generate plots are generally installation dependent and are described in Section 5 of the Programmer's Manual. There are two plot files (PLT1 and PLT2). It is only necessary to specify file PLT2. File PLT1 is reserved for future use.

The following table shows the permissible plotters and model names. The underlined items are the default models for each plotter. A model name is generally specified as two items, each having a default value. The default value of the second item is in some cases dependent upon the value specified for the first item. If no plotter is specified by the user, the requested plots will be created for the Stromberg Carlson (SC) model 4020 microfilm plotter.

Plotter Names and Models	
Name	**Model**
SC	4020
CALCØMP	{7651, 7631, 7655, 7635} , {781, 780, 773, 772, 771, 770} {5651, 5631, 5655, 5635} , {763, 762, 761, 760, 751, 750}
NASTPLT	{M, T, D} , {0, 1}

The plotter name, SC, is used for Stromberg Carlson plotters. The only permissible model is the 4020 microfilm plotter. If the only available plotter model is a 4060, the user should determine if it has a 4020 compatibility package.

The plotter name, CALCØMP, is used for California Computer plotters. The default model is a 7651,770. The first model item contains the three digits which refer to the plotter model number as used in California Computer hardware descriptions plus an additional digit referring to the increment size. The 700 series plotters are those having 16 incremental directions. The 500 series plotters are those having only 8 incremental directions. The 600 series may have either 16 or 8 incremental directions. If the user has access to only a 663 or 665 plotter, it should be specified as a 563 or 565 if it has only 8 incremental directions, and as a 763 or 765 if it has 16 incremental directions. The 563 and 763 are both 30-inch drum plotters, while the 565 and 765 are both 12-inch drum plotters.

There are two possible increment sizes, .010 and .005 inch. The last digit of the first model item represents these two possible increment sizes, i.e., 1 = .010 and 5 = .005.

The second model item indicates the type of tape transport used with the CALCØMP plotter and the number of spacers for tape densities. The first two digits of the second model item represent the type of tape transport attached to the plotter. There are numerous types of tape transports available. The primary differences among these transports are the number of characters per plot command. The 750 transport requires three characters per plot command and can only be attached to the 500 series plotters. All other transports require one character. The 760 transport is used with either the 500 or 600 series plotters. The 770 and 780 transports are used with the 600 or 700 series plotters.

The complete CALCØMP plotter card encompasses two model item codes which represent a combination of plotter model number, increment size, tape transport model number, and spacer numbers for tape densities. The following table illustrates the item codes required for the hardware available.

Calcomp Plotter Parameters								
External Model Name	Plotter Model	Increment Size (in.)	Paper Size X by Y (in. x in.)	Transport	Number of Spacers (ns)			
					A	B	C	D
7651,78(ns)	765	.01	12 X 11	780	-	0	-	1
7651,77(ns)	765	.01	12 X 11	770	0	1	2	3
7655,78(ns)	765	.005	12 X 11	780	-	0	-	1
7655,77(ns)	765	.005	12 X 11	770	0	1	2	3
7631,78(ns)	763	.01	30 X 29	780	-	0	-	1
7631,77(ns)	763	.01	30 X 29	770	0	1	2	3
7635,78(ns)	763	.005	30 X 29	730	-	0	-	1
7635,77(ns)	763	.005	30 X 29	770	0	1	2	3
5651,76(ns)	565	.01	12 X 11	760	0	1	2	3
5651,75(ns)	565	.01	12 X 11	750	0	1	2	3
5655,76(ns)	565	.005	12 X 11	760	0	1	2	3
5655,75(ns)	565	.005	12 X 11	750	0	1	2	3
5631,76(ns)	563	.01	30 X 29	760	0	1	2	3
5631,75(ns)	563	.01	30 X 29	750	0	1	2	3
5635,76(ns)	563	.005	30 X 29	760	0	1	2	3
5635,75(ns)	563	.005	30 X 29	750	0	1	2	3

A = 200 bpi tape on fast tape transport
B = 556 bpi tape on slow tape transport
C = 800 bpi tape on slow tape transport
D = 800 bpi tape on fast tape transport
Plot tapes may be seven or nine tracks (See Section 2.1).

PLOTTING

The plotter name, NASTPLT, is used for the NASTRAN General Purpose plotter package. This plotter package is used if the user's plotter is not supported by the NASTRAN plotting software. However, if this package is specified, a separate program must be written to interpret the resulting plot tape and create the corresponding plots on the actual plotter desired. The default model is M, 0. The first model item may either be M, T, or D. This indicates the actual plotter is a microfilm, table or drum plotter, respectively. The second model item indicates whether or not the actual plotter has any typing capability: 0 = typing possible, 1 = no typing possible. If no typing capability exists, all printed characters will be drawn. The default plotter type is a microfilm plotter with typing capability. An example of an acceptable model is (T,1). This represents a table plotter having no typing capability. A more detailed description of the implications of the NASTRAN General Purpose plotter package is given in Section 6 of the Programmer's Manual.

The operation of the Structure Plotter is of sufficient theoretical content to warrant inclusion in the Theoretical Manual. Section 13 of the Theoretical Manual provides a discussion of the basic theory and gives some examples of plotter output.

The availability of NASTRAN plotting capability is a function of the particular rigid format as shown in Table 1.

Table 1. Plotter available for the NASTRAN rigid formats.

Rigid Format	Structure Plotter		Curve Plotter	Matrix Topology Plotter
	Undeformed	Deformed		
1	x	x	x	*
2	x	x		*
3	x	x		*
4	x	x		*
5	x	x		*
6	x	x		*
7	x			*
8	x		x	*
9	x	x	x	*
10	x			*
11	x	x	x	*
12	x	x	x	*
13	x	x		*
14	x	x		*
15	x	x		*
1(HEAT)	x	x		*
3(HEAT)	x	x		*
9(HEAT)	x	x	x	*
10(AERØ)	x	x	x	*
11(AERØ)	x	x	x	*

* The matrix topology plotter is not automatically available in any rigid format. Utility module SEEMAT must be altered into the Rigid Format DMAP sequence in order to use this feature (see Section 5.5).

4.2 STRUCTURE PLOTTING

In order to assist NASTRAN users both in the preparation of the analytical model and in the interpretation of output, the structure plotter provides the following capabilities for undeformed structures:

1. Place a symbol at the grid point locations. (optional)
2. Identify grid points by placing the grid point identification number to the right of the grid point locations. (optional)
3. Identify elements by placing the element identification number and element label at the center of each element. (optional)
4. Identify element properties by placing the element property identification number near the element identification number and element symbol. (optional)
5. Connect the grid points in a predetermined manner using the structural elements or PLØTEL elements.
6. Reflect the symmetric portion of the structural elements about a designated axis. (optional)

The following capabilities are provided for deformed structures:

1. Place a symbol at the deflected grid point location. (optional)
2. Identify the deflected grid points by placing the grid point identification number to the right of the deflected grid point locations. (optional)
3. Identify elements by placing the element identification number and element label at the center of each element. (optional)
4. Identify element properties by placing the element property identification number near the element identification number and element symbol. (optional)
5. Connect the deflected grid points in a predetermined manner using the structural elements or PLØTEL elements.
6. Draw lines originating at the undeflected or deflected grid point location, drawn to user-specified scale, representing the X, Y, Z components or resultant summations of the grid point deflection, velocity, or acceleration vector.
7. Reflect the symmetric portion of the structural elements (which are symmetrically or antisymmetrically loaded) about a designated axis. (optional)
8. Superimpose the deflected shape over the undeflected shape. (optional)
9. Draw the outline of the structural elements which lie on the boundaries. (optional)
10. Map the deflection or stress contours of two dimensional elements. (optional)

The above plots are available in either orthographic, perspective, or stereoscopic projections on several plotters. Stereoscopic plots are normally made only on microfilm plotters since a stereoscopic viewer or projector must be used to obtain the stereoscopic effect. A request for structure

plotting is made in the Case Control Deck by means of a plot request packet which includes all cards from an ØUTPUT(PLØT) card to either a BEGIN BULK or ØUTPUT(XYØUT) [or ØUTPUT(XYPLØT)] card. It should be noted that only elements can be plotted. Grid points that are not associated with elements cannot be plotted. Grid points may be connected with PLØTEL elements for plotting purposes.

The data card format is free-field, subject to rules in paragraphs below. The cards are basically sequence dependent even though some interchanging in sequence of defining parameters is permissible. The elements and grid points to be plotted may be defined anywhere in the submittal, but the parameters describing the characteristics of the plot are evaluated on the current basis every time a PLØT or FIND card (see Section 4.2.2.2) is encountered. In order to minimize mistakes, it is suggested that a strict sequence dependency be assumed.

4.2.1 General Rules

4.2.1.1 Rules for Free-Field Card Specification

1. Only columns 1 thru 72 are available. Any information specified in columns 73 thru 80 will be ignored.
2. If the last character on a card is a comma (not necessarily in column 72), the next card is a continuation of this physical card. Any number of continuation cards may be specified, and together they form a logical card.
3. The mnemonics or values can be placed anywhere on the card, but must be separated by delimiters.
4. The following delimiters are used:
   a. blank
   b. , comma
   c. (left parenthesis
   d.) right parenthesis
   e. = equal sign

   All of these delimiters can be used as needed to aid the legibility of the data.

4.2.1.2 Plot Request Packet Card Format

In the plot request packet card descriptions presented in Section 4.2.2, the following notations will be used to describe the card format:

1. Upper-case letters must be punched exactly as shown.

2. Lower-case letters indicate that a substitution must be made.

3. Braces { } indicate that a choice of the contents is mandatory.

4. Brackets [ ] contain an option that may be omitted or included by the user.

5. Underlined options or values are those for which a default option or an initialized (or computed) value was programmed.

6. A physical card consists of information punched in columns 1 through 72 of a card.

7. A logical card may consist of more than one physical card through the use of continuation cards.

8. Numerical values may always be either integer or real numbers, even though a specific type is at times suggested in order to conform to the input in other sections of the program.

4.2.1.3 Plot Titles

Up to four lines of title information will be printed in the lower left-hand corner of each plot. The text for the top three lines is taken from the TITLE, SUBTITLE, and LABEL cards in the Case Control Deck. (See Sections 2.3.2 and 2.3.4 for a description of the TITLE, SUBTITLE, and LABEL cards.) The text for the bottom line may be of two forms depending on the type plot requested. One form contains the word UNDEFØRMED SHAPE. The other form contains the type of plot (statics, modal, etc.), subcase number, load set or mode number, frequency or eigenvalue or time, and (for complex quantities) the phase lag or magnitude.

Each plot frame, or group of frames, resulting from a single PLØT command may have a line of information to the right of the SUBTITLE text which is taken from the PTITLE card in the plot request packet (see Section 4.2.2.2).

The sequence number for each plot is printed in the upper corners of each frame. The sequence number is determined by the relative position of each PLØT execution card in the plot package. The date and (for deformed plots) the maximum deformation are also printed at the top of each frame.

4.2.2 Plot Request Packet Card Descriptions

The general form for each card of the plot request packet is shown enclosed in a rectangular box. Description of the card contents then follows for each card.

4.2.2.1 SET Definition Cards

These cards specify sets of elements, corresponding to portions of the structure, which may be referenced by PLØT and FIND cards. The SET card is required.

Each set of elements defines by implication a set of grid points connected by those elements. The set may be modified by deleting some of its grid points. The elements are used for creating the plot itself and element labeling while the grid points are used for labeling, symbol printing, and drawing deformation vectors.

$$\boxed{\begin{array}{l} \text{SET } i \ [\underline{\text{INCLUDE}}] \ [\underline{\text{ELEMENTS}}] \ j_1,\ j_2,\ j_3 \text{ THRU } j_4,\ j_5, \text{ etc.} \\ \qquad \begin{bmatrix}\text{INCLUDE}\\ \text{EXCLUDE}\\ \text{EXCEPT}\end{bmatrix} \begin{bmatrix}\text{ELEMENTS}\\ \text{GRID POINTS}\end{bmatrix} k_1,\ k_2,\ k_3 \text{ THRU } k_4,\ k_5, \text{ etc.} \end{array}}$$

i = set identification number (positive integer, unique for each set)

j = element identification numbers or element types

k = element identification numbers or grid point identification numbers or element types

Permissible element types are:

AERØ1, AXIF2, AXIF3, AXIF4, BAR, CØNE, CØNRØD, HEXA1, HEXA2, FLUID2, FLUID3, FLUID4, IHEX1, IHEX2, IHEX3, PLØTEL, QDMEM, QDMEM1, QDMEM2, QDPLT, QUAD1, QUAD2, RØD, SHEAR, SLØT3, SLØT4, TETRA, TØRDRG, TRAPAX, TRAPRG, TRBSC, TRIA1, TRIA2, TRIAAX, TRIARG, TRMEM, TRPLT, TUBE, TWIST, VISC, WEDGE

ALL may be used to select all permissible element types.

INCLUDE may be used at any time for element information. When used with grid points, INCLUDE can be used only to restore previously EXCLUDEd grid points. It cannot be used to include grid points in the original set of grid points.

EXCLUDE can be used to delete elements or element types. All grid points that are associated with deleted elements are also deleted. EXCLUDE can be used to delete deformation vectors from grid points enumerated after an EXCLUDE command.

EXCEPT is a modifier to an INCLUDE or an EXCLUDE statement.

THRU is used to indicate all of the integers in a sequence of identification numbers, starting with the integer preceding THRU and ending with the integer following THRU. The integers in the range of the THRU statement need not be consecutive, e.g., the sequence 2, 4, 7, 9 may be specified

C - 8

as 2 THRU 9.

Each SET must be a logical card. Redefinition of sets previously defined is not permitted; however, there is no restriction on the number of sets. The sets of identification numbers can be assembled by use of the word ALL, or by individually listing the integers in any order such as 1065, 32, 46, 47, 7020, or by listing sequences using THRU, EXCLUDE, and EXCEPT such as 100 THRU 1000 EXCEPT 182 EXCLUDE 877 THRU 911. Examples of SET cards:

Examples of SET cards:

1. SET 1 INCLUDE 1, 5, 10 THRU 15 EXCEPT 12
   (Set will consist of elements 1, 5, 10, 11, 13, 14 and 15)

2. SET 25 = RØD, CØNRØD, EXCEPT 21
   (Set will consist of all RØD and CØNRØD elements except element 21)

3. SET 10 SHEAR EXCLUDE GRID PØINTS 20, 30 THRU 60, EXCEPT 35, 36 INCLUDE ELEMENTS 70 THRU 80.
   (This set will include all shear elements plus elements 70 thru 80, and the associated grid point set will contain all grid points connected by these elements. Grid points 20, 30 thru 34 and 37 thru 60 will appear on all plots with their symbols and labels, however no deformation vectors will appear at these grid points when VECTØR is commanded.

4. SET (15) = (15 THRU 100) EXCEPT (21 THRU 25)
   (This set will include all elements from 15 to 20 and from 26 to 100).

5. SET 2 = ALL EXCEPT BAR
   (This set will include all elements except bars).

NOTE: The equal signs, commas, and parentheses above are delimiters and are not required, because blanks also serve as delimiters.

4.2.2.2 Cards Defining Parameters

These cards specify how the structure will be plotted, i.e., type of projection, view angles, scales, etc. All the multiple choice parameters are defaulted to a preselected choice if not specified. Each parameter requiring a numerical value that is not specified by the user can either be established internally in the program by means of the FIND card or can assume default values. The FIND card is used to request that the program select a SCALE, ØRIGIN, and/or VANTAGE PØINT to allow the construction of a plot in a user-specified region of the paper or film. The FIND card is described at the end of this Section, following the discussion of the associated parameters.

The parameter cards are listed here in a logical sequence; however, they need not be so specified. Any order may be used, but if a parameter is specified more than once, the value or choice stated last will be used. Each parameter may be either an individual card, or any number of them may be combined on one logical card.

All the parameters used in the generation of the various plots will be printed out as part of the output, whether they are directly specified, defaulted or established using the FIND card.

Initialization of parameters to default values occurs only once. Subsequently, these values remain until altered by a direct input. The only exceptions are the view angles, scale factors, vantage point parameters, and the origins. Whenever the plotter or the method of projection is changed, the view angles are reset to the default values, unless they are respecified by the user. In addition, the scale factors, vantage point parameters, and the origin must be redefined by the user.

$$\boxed{\text{PLØTTER} \left\{ \begin{matrix} \text{plotter name} \\ \underline{\text{SC}} \end{matrix} \text{, MØDEL } \begin{matrix} \text{name} \\ \underline{4020} \end{matrix} \right\} \left[\text{DENSITY} \left\{ \begin{matrix} 800 \\ 556 \\ 200 \end{matrix} \right\} \text{ BPI} \right]}$$

The plotter names and MØDEL names are listed in Section 4.1. The tape density information is used only in print-out and <u>does not control</u> the <u>density of the generated plot tape</u>. To actually specify the tape density, the user must use the customary means of communication established at a given installation between the user and the computer operators. This card is required for plotters other than the SC 4020.

$$\boxed{\left\{ \begin{matrix} \underline{\text{ØRTHØGRAPHIC}} \\ \text{PERSPECTIVE} \\ \text{STEREØSCØPIC} \end{matrix} \right\} \text{ PRØJECTIØN}}$$

The default option is orthographic projection. See Section 13 of the Theoretical Manual for a discussion of the various projections. This card is optional.

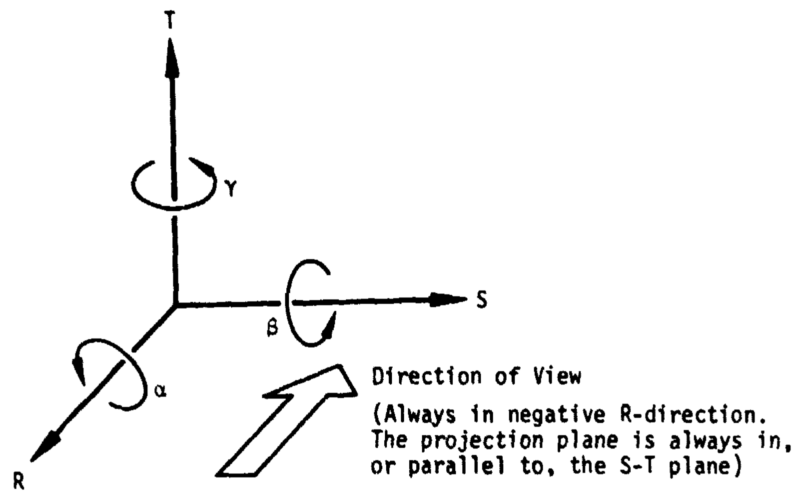
$$\boxed{\text{AXES r, s, t } \left[\left\{ \begin{matrix} \underline{\text{SYMMETRIC}} \\ \text{ANTISYMMETRIC} \end{matrix} \right\} \right]}$$

$$\boxed{\text{VIEW } \gamma, \beta, \alpha}$$

r, s, t = X or MX, Y or MY, Z or MZ (where "M" implies the negative axis)

γ, β, α = three angles of rotation in degrees (real numbers)

These two parameter cards define the orientation of the object in relation to the observer, that is, the angles of view. Both of these cards are optional. Defining the observer's coordinate system as R, S, T and the basic coordinate system of the object as X, Y, Z, the angular relationship between the two systems is defined by the three angles γ, β and α as follows:



Using the above convention, γ and β represent the angles of turn and tilt. The default values are:

γ = 34.27°

β = 23.17° for orthographic and stereoscopic projections

0.0° for perspective projection

α = 0.0° .

The order in which γ, β, and α are specified is critically important as illustrated in Figure 1, at the end of this section. Also, see section 13.1.1 of the Theoretical Manual.

The AXES card can be used to preposition the object in 90° increments in such a manner that only rotations less than 90° are required by the VIEW card to obtain the desired orientation. This is accomplished by entering X, Y, Z, MX, MY or MZ in the fields corresponding to R, S, T axes, where MX, MY and MZ represent the negative X, Y and Z axis directions respectively. The default values are X, Y, Z.

An undeformed or deformed plot of the symmetric portion of an object can be obtained by reversing the sign of the axis that is normal to the plane of symmetry. In the case of multiple planes of symmetry, the signs of all associated planes should be reversed. The ANTISYMMETRIC option should be specified when a symmetric structure is loaded in an unsymmetric manner. This will cause the deformations to be plotted antisymmetrically with respect to the specified plane or

planes. Since the AXES card applies to all parts (SETS) of a single frame, symmetric and antisymmetric combinations cannot be made with this card (see the symmetry option on the PLØT execution card in Section 4.2.2.3).

MAXIMUM DEFØRMATIØN d

This card must always be included if a deformed structure is to be plotted. The value of d represents the length to which the maximum displacement component is scaled in each subcase. The maximum deformation of the structure must be specified in units of the structure (not inches of paper). This data is necessary since the actual deformations are usually too small to be distinguishable from the undeformed structure if they were plotted to true scale. If FIND card parameters are to be based on the deformed structure, the FIND card must be preceded by the MAXIMUM DEFØRMATIØN card. If no value is defined, 5% of the maximum deformation of the structure will be used.

SCALE a[, b]

a = real number representing scale to which the model is drawn

b = ratio of model size/real object size (stereoscopic projection only)

For orthographic or perspective projections, the scale "a" is the ratio of the plotted object in inches to the real object in the units of the structural model, i.e., one inch of paper equals one unit of structure. For stereoscopic projection, the stereoscopic effect is enhanced by first reducing the real object to a smaller model (scale "b"), and then applying scale "a". The ratio of plotted/real object is then the product a x b. A scale must be defined in order to make a plot; however, the SCALE card is not recommended for general use. See the FIND card described at the end of this Section in order to have the scale determined automatically.

$\boxed{\text{ØRIGIN } i, u, v, u'}$

i = origin identification number (any positive integer)

u = horizontal displacement of paper origin from RST origin (for stereoscopic projections, the horizontal displacement of the paper origin for the left eye)

v = vertical displacement of paper origin from RST origin

u'= horizontal displacement of the paper origin for the right eye for stereoscopic projections.

In the transformation performed for any of the three projections, the origins of both the object (XYZ system) and of the observer (RST system) are assumed to be coincident.

This card refers to the paper origin. It represents the displacement of the paper origin (lower left hand corner) from the RST origin. The units are inches and are not subject to the scaling of the plotted object. The ØRIGIN card is not recommended for general use. See the FIND card described at the end of this Section in order to have the origin located so as to place the plotted object in the center of the image area.

Ten (10) origins are permitted to be active at one time. However, any one can be redefined at any time. An eleventh origin is also provided if more than 10 origins are erroneously defined (i.e., only the last of these surplus origins will be retained). CAUTION: when a new projection or plotter is called for, all previously defined origins are deleted.

$\boxed{\text{VANTAGE PØINT } r_o, s_o, t_o [, s_{or}]}$

(perspective and stereoscopic projections only)

r_o = R-coordinate of the observer

s_o = S-coordinate of the observer in perspective projection or S-coordinate of the left eye of the observer in the stereoscopic projection

t_o = T-coordinate of the observer

s_{or} = S-coordinate of the right eye of the observer in the stereoscopic (not needed in perspective) projection

This card defines the location of the observer with respect to the structural model. A vantage point is required for either perspective or stereoscopic projection. The VANTAGE PØINT card is not recommended for general use. See the FIND card described at the end of this Section. A theoretical description of vantage point is contained in Section 13 of the Theoretical Manual.

PRØJECTIØN PLANE SEPARATIØN d_o

(perspective and stereoscopic projections only)

This card specifies the R-direction separation of the observer and the projection plane.

The PRØJECTIØN PLANE SEPARATIØN card is not recommended for general use. See the FIND card described at the end of this Section. The card may be omitted if VANTAGE PØINT is included on the FIND card. A theoretical description of projection plane separation is contained in Section 13 of the Theoretical Manual.

ØCULAR SEPARATIØN $\left\{\begin{matrix}\underline{2.756}\\ os\end{matrix}\right\}$

(stereoscopic projection only)

Ocular separation - S-coordinate separation of the two vantage points in the stereoscopic projection is defaulted to 2.756 inches which is the separation used in the standard stereoscopic cameras and viewers (70mm). It is recommended that the default value be used.

CAMERA $\left\{\begin{matrix}\text{FILM}\\ \underline{\text{PAPER}}\\ \text{BØTH}\end{matrix}\right\}$ $\left[\text{, BLANK FRAMES} \left\{\begin{matrix} n\\ \underline{1}\end{matrix}\right\}\right]$

(microfilm plotters only)

This card offers three options of different cameras or combinations:

FILM - 35mm or 16mm film (positive or negative images)

PAPER - positive prints

BØTH - positive prints and 35mm or 16mm film

The request for a 35mm or 16mm camera and positive or negative images must be communicated to the plotter operator through normal means of communications at the installation. Insertion of blank frames between plots is optional and is applicable only to plots generated on film, i.e., the option FILM or BØTH must be selected if blank frames are desired. The plotter must be operated in the manual mode in order to have blank frames inserted between positive prints. If blank frames are desired only on film, and not on paper, the plotter must be operated in the automatic mode. The

default values are PAPER and n = 1. This card is completely optional.

$$\text{PAPER SIZE} \begin{Bmatrix} a \\ \underline{8.5} \end{Bmatrix} \begin{Bmatrix} x \\ \text{BY} \end{Bmatrix} \begin{Bmatrix} b \\ \underline{11.0} \end{Bmatrix} \left[, \text{TYPE} \begin{Bmatrix} \text{BCD value} \\ \underline{\text{VELLUM}} \end{Bmatrix} \right]$$

(table plotters only)

a = horizontal size of paper in inches

b = vertical size of paper in inches

value = any BCD value desired by user for identification purposes.

The default parameters are 8.5 x 11.0, type VELLUM. This card is completely optional.

$$\text{PEN} \begin{Bmatrix} i \\ \underline{1} \end{Bmatrix} \left[, \text{SIZE} \begin{Bmatrix} j \\ \underline{1} \end{Bmatrix} \right] \left[, \text{CØLØR} \begin{Bmatrix} \text{name} \\ \underline{\text{BLACK}} \end{Bmatrix} \right]$$

(table plotters only)

i = pen designation number

j = pen size number (0 thru 3)

name = color desired

The default parameters are PEN 1, SIZE 1, CØLØR BLACK.

This card generates a message on the printed output which may be used for the purpose of informing the plotter operator as to what size and which color pen point to mount in the various pen holders. The actual number of pens available will depend on the plotter hardware configuration at each installation. This card does not control the pen used in generating the plot (see the PEN option on the PLOT execution card in Section 4.2.2.3). The PEN card is optional, and is not appropriate for microfilm plotters.

The pen designations vary on various plotters; therefore, the designation numbers used here are only the pointers to true identification of the pens. The following table summarizes these pen designations and the actual pen numbers on the plotters used.

NASTRAN Pen Designation	PLOTTER Pen Number
1	1
2	2
3	3
4	4
5	1
6	2
7	3
8	4

FIND [SCALE f],[ØRIGIN i],[VANTAGE PØINT],[SET j],[REGIØN le,be,re,te]

f = ratio by which the scale is multiplied after it is calculated.

i = origin identification number (any positive integer).

j = set identification number (any positive integer).

le = fractional distance of left edge of plot region from the lower left corner of the image area (default value = 0).

be = fractional distance of bottom edge of plot region from the lower left corner of the image area (default value = 0).

re = fractional distance of right edge of plot region from the lower left corner of the image area (default value = 1.).

te = fractional distance of top edge of plot region from the lower left corner of the image area (default value = 1.).

The FIND card requests the structure plotter to compute any of the parameters SCALE, ØRIGIN i and/or VANTAGE PØINT indicated by the user based on (a) the plotter requested on the PLØTTER card, (b) the projection requested on the PRØJECTION card, (c) SET j and REGIØN le, be, re, te requested on the FIND card, (d) the orientation requested on the VIEW and/or AXES card(s), (e) the deformation scaling requested on the MAXIMUM DEFØRMATIØN card, and (f) the paper size for table plotters as requested on the PAPER SIZE card. All dependencies on which a FIND card is based must precede the FIND card.

Any one, two, or all three parameters may be computed by the program by using this card, provided that the parameters not requested have already been defined. If no set is specified on this card, the first set defined is used by default. If no options are specified on the FIND card, a SCALE and VANTAGE PØINT are selected and ØRIGIN 1 is located, using the first defined SET, so that the plotted object is located within the image area. The plot region is defined as some fraction of the image area (image area = 0, 0, 1., 1. and first quadrant = .5, .5, 1., 1.). The image area is located inside the margins on the paper. Each FIND card must be one (1) logical card. The FIND card is recommended for general use.

```
PTITLE  [blanks    ]
        [BCD string]
```

The title may be up to 64 characters. This card defines the plot title for a series of plots. A plot title card remains in effect until a new plot title is defined. To eliminate a title, a new plot title card which contains only blanks must be defined.

The title card must preceed the PLØT card to which it pertains. If a PLØT card generates several plot frames, the preceeding title card will apply to all the frames.

The contour plot definition card is used to specify the type of contour plot and the contour values to be plotted. The card is optional since all parameters may be defaulted.

```
CØNTØUR  [stress      ] , [EVEN 10          ] , [Z1 ] , [{CØMMØN} direction]
         [displacement]   [LIST c1,c2,...,cn]   [Z2 ]   [{LØCAL }          ]
                          [EVEN n           ]   [MAX]
                                                [MID]
```

Nine types of stress coutour plots are available:

stress =	MAJPRIN MINPRIN	- Major and Minor Principal Stress
	MAXSHEAR	- Maximum Shear Stress
	XNØRMAL YNØRMAL ZNØRMAL	- X, Y, and Z Components of the Normal Stress
	XYSHEAR XZSHEAR YZSHEAR	- XY, XZ, and YZ Components of the Shear Stress

Four types of displacement contour plots are available:

displacement =	XDISPLAC YDISPLAC ZDISPLAC	- the X, Y, and Z components of the displacement vector
	MAGNITUD	- the magnitude of the displacement vector

Default for this parameter is MAJPRIN, Major Principal Stress.

If stress contour is requested, contour lines will be plotted on the following elements appropriate to the type of stress contour plot requested: SHEAR, TRIA1, TRIA2, QUAD1, QUAD2, TRMEM, and QDMEM.

If displacement contour is requested, contour lines will be plotted on all two dimensional elements plotted by the structure plotter. The type of deformation must be specified for displacement contours since there is no default.

The contour lines are labeled with integers indicating the contour value. The integers are listed with their associated contour values under MESSAGES FRØM THE PLØT MØDULE in the printed output.

The contour values to be plotted may be specified by supplying the parameter EVEN and the number, n, of contour values, or by supplying LIST with a list of real number contour values. If EVEN is specified, the contour plotter will calculate n contour values at (n-1) equal intervals over the range of values specified by the user. The first contour value will be the minimum and the n-th contour value the maximum of the values for the current set of elements. The maximum number of contour values, n, is 50. Default for this parameter is "EVEN 10", i.e., contour values at 10 equal intervals.

Since stress may be calculated at two fibre distances, the fibre distance may be specified by designating Z1 (Fibre Distance 1) or Z2 (Fibre Distance 2). In addition, MAX, the maximum of Z1 and Z2, or MID, the average of Z1 and Z2, may be selected. The average of Z1 and Z2 (MID) is applicable only to the TRIA2 and QUAD2 elements. The Fibre Distance Z1 must be used for TRMEM, QDMEM, and SHEAR elements. The default is Z1.

The Normal Stresses are directional and are calculated in the elements' local coordinate system. If CØMMØN direction is specified, the contour plotter will transform the Normal Stresses and the Shear Stresses to a common (the basic) coordinate system. If LØCAL direction is specified, the contour plotter will leave these stresses in the global coordinate system. Note that the Normal Z Stress, and the Shear-XZ and Shear-YZ are assumed to be zero in the element's local coordinate system. Default for this parameter is the CØMMØN direction.

The following table summarizes the recognizable options associated with stress contour requests.

Element Name	Stress Option	Stress Location	Coordinate System
TRIA1	MAJPRIN	Z1, Z2, or MAX	LØCAL
QUAD1	MINPRIN		LØCAL
TRPLT or	MAXSHEAR		LØCAL
QDPLT	XNØRMAL		CØMMØN or LØCAL
	YNØRMAL		CØMMØN or LØCAL
	ZNØRMAL		CØMMØN
	XYSHEAR		CØMMØN or LØCAL
	XZSHEAR		CØMMØN
	YZSHEAR		CØMMØN
	MAJPRIN	MID	LØCAL
TRIA2	MINPRIN		LØCAL
QUAD2 or	MAXSHEAR		LØCAL
TRBSC	XNØRMAL		CØMMØN or LØCAL
	YNØRMAL		CØMMØN or LØCAL
	ZNØRMAL		CØMMØN
	XYSHEAR		CØMMØN or LØCAL
	XZSHEAR		CØMMØN
	YZSHEAR		CØMMØN
TRMEM	MAJPRIN	Z1	LØCAL
QDMEM	MINPRIN		LØCAL
QDMEM1 or	MAXSHEAR		LØCAL
QDMEM2	XNØRMAL		CØMMØN or LØCAL
	YNØRMAL		CØMMØN or LØCAL
	ZNØRMAL		CØMMØN
	XYSHEAR		CØMMØN or LØCAL
	XZSHEAR		CØMMØN
	YZSHEAR		CØMMØN
SHEAR	MAXSHEAR	Z1	LØCAL

4.2.2.3 PLØT Execution Card

```
     ┌┌STATIC     ┐┐  ┌┌DEFØRMATIØN ┐┐                                  ┌┌RANGE f1, f2 ┐┐  ┌┌PHASE LAG φ┐┐
     │|MØDAL      |│  ││VELØCITY    ││                                  ││RANGE λ1, λ2 ││  ││MAGNITUDE  ││
PLØT │<CMØDAL     >│  │<ACCELERATIØN>│[CØNTØUR][i1, i2 THRU i3, etc.]│<TIME  t1, t2 >│  │<           >│.
     │|FREQUENCY  |│  └└            ┘┘                                  └└             ┘┘  └└           ┘┘
     └└TRANSIENT  ┘┘

[MAXIMUM DEFØRMATIØN d],

                            ┌┌SYMMETRY     ┐  ┐ ┌┌PEN     ┐  ┐                    ┌      ┌GRID PØINTS┐┐
[SET j1][ØRIGIN k1]│<ANTISYMMETRY >w│ │<DENSITY >p│[SYMBØLS m[, n]]│LABEL│ELEMENTS   ││.
                            └└             ┘  ┘ └└        ┘  ┘                    │      │BØTH       ││
                                                                                  └      └EPID       ┘┘

┌SHAPE            ┐
│VECTØR v         │
│SHAPE, VECTØR v  │.
└ØUTLINE          ┘

[SET j2][ØRIGIN k2] .... etc.
```

This logical card will cause one picture to be generated for each subcase, mode or time step requested, using the current parameter values. If only the word PLØT appears on the card, a picture of the undeformed structure will be prepared using the first defined set and the first defined origin. The available plot options and their meanings are:

1. STATIC - Plot static deformations in Rigid Formats 1, 2, 4, 5, 6 and 14; Heat Rigid Formats 1 and 3; Aero Rigid Format 11.

   MØDAL - Plot mode shapes in Rigid Formats 3, 5, 13 and 15.

   CMØDAL - Plot mode shapes in Aero Rigid Format 10.

   FREQUENCY - Plot frequency deformations in Rigid Format 11 and Aero Rigid Format 11.

   TRANSIENT - Plot transient deformations in Rigid Formats 9 and 12; Heat Rigid Format 9; Aero Rigid Format 11.

2. DEFØRMATIØN - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" command.

   VELØCITY - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.

   ACCELERATIØN - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases.

3. CØNTØUR - Refers to stress or displacement contour lines and values. If deformed plots are requested, then the contours will be drawn on the deformed shape. If an underlay is requested (via "0" in the subcase string), the contours will be drawn on the undeformed shape.

4. i1, i2, ... - Nonzero integers following refer to subcases that are to be plotted. Default is all subcases. See SHAPE and VECTØR for use of "0" (underlay) command.

5. RANGE - Refers to range of eigenvalues (Rigid Format 5) or frequencies (Rigid Formats 3, 10, 11, 13, and 15), using requested subcases, for which plots will be prepared.

   TIME - Refers to time interval, using requested subcases and output time steps, for which plots will be prepared (Rigid Formats 9 and 12).

6. PHASE LAG - Real number, ϕ, in degrees (default is 0.0). The plotted value is $u_R \cos \phi - u_I \sin \phi$, where u_R and u_I are the real and imaginary parts of the response quantity (Rigid Formats 10 and 11).

   MAGNITUDE - Plotted value is $\sqrt{u_R^2 + u_I^2}$.

7. MAXIMUM DEFØRMATIØN - Real number following is used as the maximum displacement component in scaling the displacements for all subcases. Each subcase is separately scaled according to its own maximum if this item is absent.

8. SET - Integer following identifies a set which defines the portion of the structure to be plotted. Default is first set defined.

9. ØRIGIN - Integer following identifies the origin to be used for the plot. Default is first origin defined.

10. SYMMETRY w - Prepare an undeformed or deformed plot of the symmetric portion of the object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k, and will appear as a reflection about the plane whose normal is oriented parallel to the coordinate direction w.

    ANTISYMMETRY w- Prepare a deformed plot of the symmetric portion of the antisymmetrically loaded object which is defined by SET j. This symmetric portion will be located in the space adjacent to the region originally defined by ØRIGIN k, and will appear as a reflection of the antisymmetrically deformed structure about the plane whose normal is oriented parallel to the coordinate direction w.

The symbol w may specify the basic coordinates X, Y, or Z or any combination thereof. This option allows the plotting of symmetric and/or antisymmetric combinations, provided that an origin is selected for the portion of the structure defined by the bulk data that allows sufficient room for the complete plot. This does not permit the combination of symmetric and antisymmetric subcases, as each plot must represent a single subcase. In the case of a double reflection, the figure will appear as one reflected about the plane whose normal is parallel to the first of the coordinates w, followed by a reflection about the plane whose normal is oriented parallel to the second of the coordinates w. This capability is primarily used in the plotting of structures that are loaded in a symmetric or an antisymmetric manner. The plane of symmetry must be one of the basic coordinate planes.

11. PEN - Integer following controls the internal NASTRAN pen number (see table in Section 4.2.2.2) that is used to generate the plot on table plotters.

    DENSITY - Integer following specifies line density for film plotters. A line density of d is d times heavier than a line density of 1.

12. SYMBØLS m[,n] - All of the grid points associated with the specified set will have symbol m overprinted with symbol n printed at its location. If n is not specified, only symbol m will be printed. Grid points excluded from the set will not have a symbol. Grid points in an undeformed underlay will be identified with symbol 2.

Following is a table of symbols available on each plotter (X indicates symbol is available). Symbols that are not available on a given plotter are defaulted to a similar symbol whose number is indicated in parentheses.

SYMBØL NØ.	SYMBØL	AVAILABILITY	
m or n		SC4020	All Others
0	no symbol	X	X
1	X	X	X
2	*	X	X
3	+	X	X
4	-	X	X
5	●	X	X
6	○	X	X
7	□	X	X
8	◊	(7)	X
9	△	(7)	X

13. LABEL GRID PØINTS - All the grid points associated with the specified set have their identification number printed to the right of the undeflected or deflected location (undeflected location in the case of superimposed plots).

LABEL ELEMENTS - All the elements included in the specified set are identified by the element identification number and type at the center of each element (undeflected location in the case of superimposed plots).

LABEL BØTH - Label both the grid points and elements.

Labels for element types are given in the following table:

Element Type	Plot Label		Element Type	Plot Label
AERØ1	AE		QUAD2	Q2
AXIF2	A2		RØD	RD
AXIF3	A3		SHEAR	SH
AXIF4	A4		SLØT3	S3
BAR	BR		SLØT4	S4
CØNE	CN		TETRA	TE
CØNRAD	CR		TØRDRG	TR
DUMi	Di(i=1-9)		TRAPAX	T4
HBDY	HB		TRAPRG	TA
HEXA1	H1		TRBSC	TB
HEXA2	H2		TRIAAX	T3
FLUID2	F2		TRIA1	T1
FLUID3	F3		TRIA2	T2
FLUID4	F4		TRIM6	T6
IHEX1	XL		TRIRG	TI
IHEX2	XQ		TRMEM	TM
IHEX3	XC		TRPLT	TP
PLØTEL	PL		TRPLT1	P6
QDMEM	QM		TRSHL	SL
QDMEM1	M1		TUBE	TU
QDMEM2	M2		TWIST	TW
QDPLT	QP		VISC	VS
QUAD1	Q1		WEDGE	WG

LABEL EPID - All the elements included in the specified set are identified by the element property identification number (in addition to the element identification number and type) at the center of each element type (undeflected location in the case of superimposed plots). Note that LABEL EPID causes element and property labels to be printed, but LABEL ELEMENT results only in element labels.

14. SHAPE - All the elements included in the specified set are shown by connecting the associated grid points in a predetermined manner.

Both deformed and undeformed shapes may be specified. All of the deformed shapes relating to the subcases listed may be underlaid on each of their plots by including "0" with the subcase string on the PLØT card. The undeformed plot will be drawn using PEN 1 or DENSITY 1 and symbol 2 (if SYMBØLS is specified).

15. VECTØR v - A line will be plotted at the grid points of the set, representing in length and direction the deformation of the point.

Vectors representing the total deformation or its principal components may be plotted by insertion of the proper letter(s) for variable v. Possible vector combinations are:

X or Y or Z	- requesting individual components
XY or XZ or YZ	- requesting 2 specified components
XYZ	- requesting all 3 components
RXY or RXZ or RYZ	- requesting vector sum of 2 components
R	- requesting total vector deformation
N	- used with any of the above combinations to request no underlay shape be drawn.

All plots requesting the VECTØR option shall have an underlay generated of the undeformed shape using the same sets, "PEN 1" or "DENSITY 1," and symbol 2 (if SYMBØLS is specified). If "SHAPE" and "VECTØR" are specified, the underlay will depend on whether "0" is used with DEFØRMATIØN. It will be the deformed shape when not used and will be both deformed and undeformed shapes when it is used. The part of the vector at the grid point will be the tail when the underlay is undeformed and the head when it is deformed. If the "N" parameter is used, no shape will be drawn but other options such as SYMBØLS will still be valid.

16. ØUTLINE - Connecting lines between grid points that lie on the boundary of the structural model will be plotted. The outline will reflect the deformed shape unless "0" is included in the subcase string. The ØUTLINE option will be ignored if the CØNTØUR option is not also requested.

4.2.2.4 Examples of PLØT Cards

1. PLØT

Undeformed SHAPE using first defined SET, first defined ØRIGIN and PEN 1 (or DENSITY 1).

2. PLØT SET 3 ØRIGIN 4 PEN 2 SHAPE SYMBØLS 3 LABEL

Undeformed SHAPE using SET 3, ØRIGIN 4, PEN 2 (or DENSITY 2) with each grid point of the set having a + placed at its location, and its identification number printed adjacent to it.

3. PLØT MØDAL DEFØRMATIØN 5 SHAPE

Modal deformations as defined in subcase 5 using first defined SET, first defined ØRIGIN, and PEN 1 (or DENSITY 1). Subcases must have previously been defined in the Case Control Deck via the use of MØDES cards, otherwise all modes will be in an assumed subcase 1.

4. PLØT STATIC DEFØRMATIØN 0, 3 THRU 5, 8 PEN 4, SHAPE

Static deformations as defined in subcases 3, 4, 5 and 8, deformed SHAPE; drawn with PEN 4, using first defined SET and ØRIGIN, underlayed with undeformed SHAPE drawn with PEN 1. This command will cause four plots to be generated.

5. PLØT STATIC DEFØRMATIØN 0 THRU 5,

SET 2 ØRIGIN 3 PEN 3 SHAPE,

SET 2 ØRIGIN 4 PEN 4 VECTØRS XYZ SYMBØLS 6,

SET 35 SHAPE

Deformations as defined in subcases 1, 2, 3, 4, and 5, undeformed underlay with PEN 1, consisting of SET 2 at ØRIGIN 3, SET 2 at ØRIGIN 4 (with an * placed at each grid point location), and SET 35 at ØRIGIN 4. Deflected data as follows: SHAPE using SET 2 at ØRIGIN 3 (PEN 3) and SET 35 at ØRIGIN 4 (PEN 4); 3 VECTØRS (X, Y and Z) drawn at each grid point of SET 2 at ØRIGIN 4 (Pen 4) (less any excluded grid points), with O placed at the end of each vector.

6. PLØT STATIC DEFØRMATIØNS 0, 3, 4,

SET 1 ØRIGIN 2 DENSITY 3 SHAPE,

SET 1 SYMEMTRY Z SHAPE,

SET 2 ØRIGIN 3 SHAPE,

SET 2 SYMMETRY Z SHAPE

Static deformations as defined in subcases 3 and 4, both halves of a problem solved by symmetry using the X-Y principal plane as the plane of symemtry. SET 1 at ØRIGIN 2 and SET 2 at ØRIGIN 3, with the deformed shape plotted using DENSITY 3 and the undeformed structure plotted using DENSITY 1. The deformations of the "opposite" half will be plotted to correspond to symmetric loading. This command will cause two plots to be generated.

7. PLØT TRANSIENT DEFØRMATIØN 1, TIME 0.1, 0.2, MAXIMUM DEFØRMATIØN 2.0, SET 1, ØRIGIN 1,

PEN 2, SYMBØLS 2, VECTØR R

Transient deformations as defined in subcase 1 for time = 0.1 to time = 0.2, using SET 1 at ØRIGIN 1. The undeformed shape using PEN or DENSITY 1 with an * at each grid point location will be drawn as an underlay for the resultant deformation vectors using PEN or DENSITY 2 with an * typed at the end of each vector drawn. In addition a plotted value of 2.0 will be used for the single maximum deformation occuring on any of the plots produced. All other deformations on all other plots will be scaled relative to this single maximum deformation. This command will cause a plot to be generated for each output time step which lies between 0.1 and 0.2.

8. PLØT CMØDAL DEFØRMATIØN PHASE LAG 90. SET 1 VECTØR R

The imaginary part of the complex mode shape will be plotted for SET 1.

9. PLØT CØNTØUR 2

PLØT CØNTØUR 2 ØUTLINE

CØNTØUR MINPRIN

PLØT STATIC DEFØRMATIØN CØNTØUR 1 ØUTLINE

The first PLØT card will cause Major Principal Stress contours to be plotted on the undeformed shape of the complete model and the second PLØT card will cause the outline of the model to be plotted due to the defaults associated with the CØNTØUR card. Contour stress plots of the Minor Principal Stress will be plotted on the outline of the deformed shape by the third PLØT card.

4.2.3 Summary of Structure Plot Request Packet Cards

SET Definition - Required

SET i [INCLUDE][ELEMENTS] j_1, j_2, j_3 THRU j_4, j_5, etc.

$\begin{bmatrix}\text{INCLUDE}\\\text{EXCLUDE}\\\text{EXCEPT}\end{bmatrix}\begin{bmatrix}\text{ELEMENTS}\\\text{GRID PØINTS}\end{bmatrix}$ k_1, k_2, k_3 THRU k_4, k_5, etc.

Parameter Definition - Optional, except as noted

PLØTTER $\left\{\begin{matrix}\text{plotter name}\\\underline{\text{SC}}\end{matrix}\right\}$, MØDEL $\left\{\begin{matrix}\text{name}\\\underline{4020}\end{matrix}\right\}$ $\left[\text{DENSITY}\left\{\begin{matrix}800\\556\\200\end{matrix}\right\}\text{ BPI}\right]$ (Required if not SC-4020)

$\left\{\begin{matrix}\underline{\text{ØRTHØGRAPHIC}}\\\text{PERSPECTIVE}\\\text{STEREØSCØPIC}\end{matrix}\right\}$ PRØJECTIØN

AXES r, s, t $\left[\left\{\begin{matrix}\underline{\text{SYMMETRIC}}\\\text{ANTISYMMETRIC}\end{matrix}\right\}\right]$

VIEW γ, β, α

SCALE a[, b] (Required if not on FIND card)

ØRIGIN i, u, v (Required if not on FIND card)

VANTAGE PØINT $r_o, s_o, t_o[, s_{or}]$ (Required for perspective and steroscopic projections if not on FIND card)

PRØJECTIØN PLANE SEPARATIØN d_o (Required for perspective and steroscopic projections if VANTAGE PØINT not on FIND card)

ØCULAR SEPARATIØN $\left\{\begin{matrix}\underline{2.756}\\\text{os}\end{matrix}\right\}$

MAXIMUM DEFØRMATIØN d (Required if deformed shapes are to be drawn)

PEN $\left\{\begin{matrix}i\\\underline{1}\end{matrix}\right\}$ $\left[\text{, SIZE}\left\{\begin{matrix}j\\\underline{1}\end{matrix}\right\}\right]$ $\left[\text{, CØLØR}\left\{\begin{matrix}\text{name}\\\underline{\text{BLACK}}\end{matrix}\right\}\right]$

STRUCTURE PLOTTING

CAMERA {FILE | PAPER | BØTH} [BLANK FRAMES {n | 1}]

PAPER SIZE {a | 8.5} {x | BY} {b | 11.0} [, TYPE {BCD value | VELLUM}]

PTITLE [blanks | BCD string]

FIND Card - Optional

FIND [SCALE f],[ØRIGIN i],[VANTAGE PØINT],[SET j], [REGIØN le, be, re, te]

PLØT Execution Card - Required

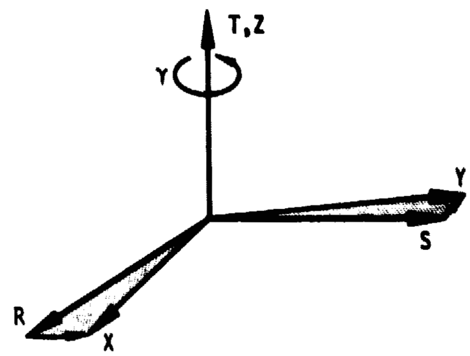
PLØT [{STATIC | MØDAL | CMØDAL | FREQUENCY | TRANSIENT}] [{DEFØRMATIØN | VELØCITY | ACCELERATIØN}] [CØNTØUR] [i1, i2 THRU i3, etc.] [{RANGE f1, f2 | RANGE λ1, λ2 | TIME t1, t2}] [{PHASE LAG φ | MAGNITUDE}],

[MAXIMUM DEFØRMATIØN d],

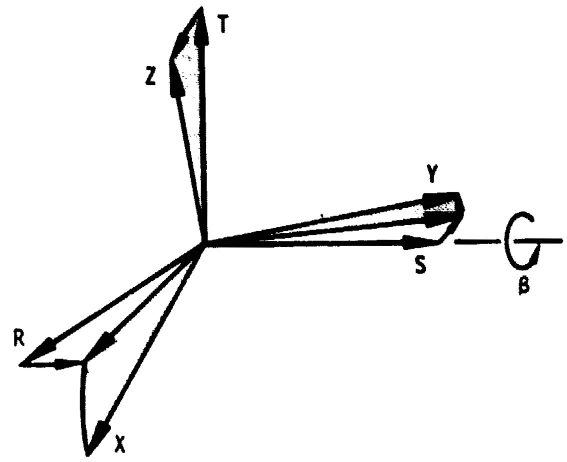
[SET j1][ØRIGIN k1] [{SYMMETRY | ANTISYMMETRY} w] [{PEN | DENSITY} p] [SYMBØLS m[, n]] [LABEL [GRID PØINTS | ELEMENTS | BØTH | EPID]],

[SHAPE | VECTØR v | SHAPE, VECTØR v | ØUTLINE],

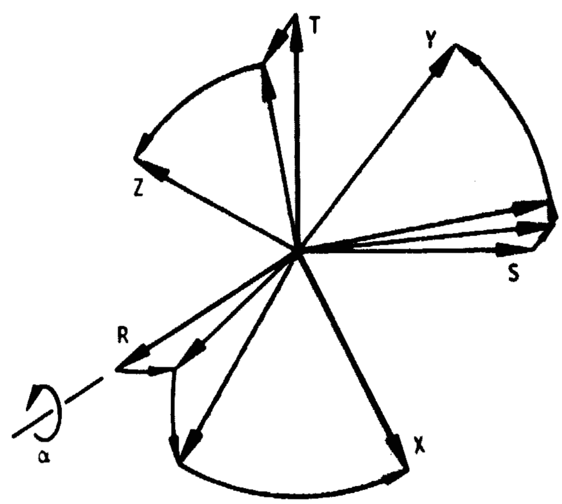
[SET j2][ØRIGIN k2] .... etc.



(a) γ - rotation about T-axis.



(b) β – rotation about S-axis



(c) α - rotation about R-axis

Figure 1. Plotter coordinate system-model orientation.

4.2.4 Error Messages

The structure plotter contains messages related to plot request(s) that are not in the same format as messages described in Section 6. These messages are warnings and notify the user that the erroneous plot request is being ignored. Only the legitimate plot requests will be honored (if there are any).

The messages and their meanings are as follows:

1. NØ PLØTTABLE STRUCTURAL ELEMENTS EXIST IN SET ********.

   This message is issued when a SET is defined which contains elements not permitted as described in Section 4.2.2.1. If a SET is defined that has some elements plottable and some not, the message is not issued and the resulting plot contains only the plottable elements.

2. ALL REFERENCES TØ SET ******** WILL DEFAULT TØ FIRST SET DEFINED.

   This message is issued when a SET is referenced on a PLØT card that either does not exist or has been eliminated previously due to another error.

3. REFERENCE TØ SET ******** ØN FIND CARD WILL DEFAULT TØ FIRST DEFINED SET.

   This message is issued when a SET is referenced on a FIND card that either does not exist or has been eliminated previously due to another error.

4. MAXIMUM DEFØRMATIØN CARD NEEDED - 5 PER CENT ØF MAXIMUM USED.

   This message is issued when the MAXIMUM DEFØRMATIØN card is not positioned properly in the plot request package or has not been defined.

5. AN UNRECØGNIZABLE ØPTIØN (********) WAS DETECTED ON A -PLØT- CARD

   This message is issued when illegal, out of sequence, or mispelled options appear on a PLØT card. The plot will be prepared, if possible, from the remaining information.

6. A NØN-EXISTENT ØRIGIN (********) HAS BEEN SPECIFIED ØN A -PLØT- CARD.

   This message is issued when an ØRIGIN has not been defined or has been previously eliminated by another error.

7. A NØN-EXISTENT SET (********) HAS BEEN SPECIFIED ØN A -PLØT- CARD.

   This message is issued when a SET has not been defined or has been previously eliminated by another error.

8. THE -****- PLØT FILE HAS NØT BEEN SET UP...PLØT CARD IGNØRED

   This message is issued when the plot file has not been assigned to tape or disk. No plots possible.

9. INSUFFICIENT CØRE FØR SET (********). CØRE AVAILABLE = ********, NEEDED = ********.

   This message is issued when insufficient core is available to process the SET defined. Either increase the core or reduce the size of the SET to subSETs.

10. *** A PLØT NØT ATTEMPTED DUE TØ INPUT ØR FILE ***.

    This message is issued when a PLOT command contradicts Case Control. For example, requesting plots for a SUBCASE, EIGENVALUE, LØAD, TIME, or FREQUENCY that does not exist would be contradictory. No plots possible.

11. *** INCØMPLETE PLØT DUE TØ INPUT ØR FILE ***.

    This message is issued for the same reasons as in the preceeding message, except some plotting is possible because not all plot requests are contradictory.

12. NØ STRESS CALCULATIØN FØUND FØR ELEMENT NUMBER ******** ELEMENT IGNØRED.

    This message is issued when a STRESS contour plot is requested but STRESS computations were not requested in Case Control.

13. MØRE THAN 50 CØNTØURS SPECIFIED *** REJECTED.

    This message is issued for all contour plot requests beginning with the fifty-first request.

4.3 X-Y ØUTPUT

In rigid formats used for transient response, frequency response (including random response), and flutter analysis, the amount of output data generated is voluminous. In order to aid the user in assimilating this vast amount of data, the X-Y output processing modules XYTRAN and XYPLØT have been provided. The primary purpose of these modules is to generate plotted graphs of y(x) where x is frequency, time, or velocity and y is any response quantity selected by the user for observation. The user is not required to specify any parametric data for the X-Y plotter; however, he may do so if he wishes in order to obtain desired scales, regions of observation, etc.

In addition to (or in place of) the plots, X-Y tabular output may be printed or punched, and summary data (e.g., maximum and minimum values and locations of these values) may be obtained for any X-Y output.

The X-Y output described above is obtained by the user via the X-Y output request packet of the Case Control Deck. This packet includes all cards between ØUTPUT(XYPLØT) [or ØUTPUT(XYØUT)] and either BEGIN BULK or ØUTPUT(PLØT). The remainder of this section describes the X-Y output request data cards and the rules for writing them. Examples are provided to illustrate the use of this feature.

4.3.1 X-Y Plotter Terminology

A single set of plotted X-Y pairs is known as a "curve". Curves are the entities that the user requests to be plotted. The surface (paper, microfilm frame, etc.) on which one or more curves is plotted is known as a "frame". Curves may be plotted on a whole frame, an upper half frame, or a lower half frame. Grid lines, tic marks, axes, axis labeling and other graphic control items may be chosen by the user. The program will select defaults for parameters not selected by the user.

Only three cards are required for an X-Y plot request. The required cards are:

1. X-Y output request packet identifier - ØUTPUT(XYPLØT) or ØUTPUT(XYØUT).
2. Plotter selection card.
3. At least one command operation card.

The terms ØUTPUT(XYPLØT) and ØUTPUT(XYØUT) are interchangeable and either form may be used for any of the X-Y output requests. The plotter selection card is described as item 1 in Section 4.3.2.1.

If the output is limited to printing and/or punching the plotter selection card is not required. The command operation card is used to request the various forms of X-Y output. This card is described in Section 4.3.3.

If only the required cards are used, the graphic control items will all assume default values. Curves using all default parameters have the following general characteristics:

1. Tic marks are drawn on all edges of the frame. Five spaces are provided on each edge of the frame.
2. All tic marks are labeled with their values.
3. Linear scales are used.
4. Scales are selected such that all points fall within the frame.
5. The plotted points are connected with straight lines.
6. The plotted points are not identified with symbols.

The above characteristics may be modified by inserting any of the parameter definition cards, described in Section 4.3.2, ahead of the command operation card or cards. The use of a parameter definition card sets the value of that parameter for all following command operation cards unless the CLEAR card is inserted (see item 16 of Section 4.3.2.1). If grid lines are requested, they will be drawn at the locations of all tic marks that result from defaults or user request. The locations of tic marks (or grid lines) for logarithmic scales cannot be selected by the user. Default values for logarithmic spacing are selected by the program. The default values for the number of tic marks (or grid lines) per cycle depend on the number of logarithmic cycles required for the range of the plotted values.

The definition notation used in Section 4.2.1.2 also applies to the X-Y plotter. Each frame, or group of frames, resulting from a single XYPLØT command will include the information from the TITLE, SUBTITLE, and LABEL cards in the Case Control Deck, the frame sequence number, and the date as described in Section 4.2.1.3. Other titling information relative to axes and curves is discussed in Section 4.3.2.

The definition and rules for the X-Y output request packet cards follow. The form of most statements used in the X-Y output request packet differs from that of similar cards used in the structure plotter request packet. The user is cautioned to prepare his input decks as specified herein.

4.3.2 Parameter Definition Cards

4.3.2.1 Cards Pertaining to All Curves

1. PLØTTER = plotter name, model name

   Selects plotter; required if plots are requested. Plotter choices are listed in Section 4.1, but there is no default. (Note: one or both of the plot tapes must be set up. See Section 5 of the Programmer's Manual for instructions.)

2. CAMERA = c (Integer)

   Used for microfilm plotters only to select camera as follows: $c \leq 1$ for film, $c = 2$ for paper, $c \geq 3$ for both; default value is 3.

3. PENSIZE = ps (Integer ≥ 0)

   Used to select pen for table plotter; default value is 1. (See Section 4.2.2.2)

4. DENSITY = d (Integer ≥ 0)

   Used to select line density for microfilm plotters only; default value is 1. A line density of d is d times heavier than a line density of 1.

5. SKIP = s (Integer ≥ 0)

   Used to insert s blank frames between requested frames for microfilm plotters; default value is 1.

6. XPAPER = x (Real)
   YPAPER = y (Real)

   Defines paper size (x by y) for table plotters; default value is x = 8.5 inches and y = 11.0 inches.

7. XMIN = x1 (Real)
   XMAX = x2 (Real)

   Specifies limits of x1 and x2 as abscissa of curve; default values are chosen so as to accommodate all points.

8. XLØG = $\left\{ \begin{array}{l} \text{YES} \\ \underline{\text{NØ}} \end{array} \right\}$

   Request for logarithmic x-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table at end of this Section).

9. YAXIS = $\left\{ \begin{array}{l} \text{YES} \\ \underline{\text{NØ}} \end{array} \right\}$

   Request for plotting y-axis; default value is NØ.

10. XINTERCEPT = xi (Real)

    Location on the x-axis (xi) where the y-axis will be drawn; default value is 0.0.

11. UPPER TICS = ut (Integer*)

Any integer value (ut) causes tic marks to be drawn on the upper edge of the frame; default value is integer one.

12. LØWER TICS = lt (Integer*)

Any integer value (lt) causes tic marks to be drawn on the lower edge of the frame; default value is integer one.

13. CURVELINESYMBØL = cls (Integer)

Request for points to be connected by lines (cls = 0), identified by symbol |cls| (cls < 0), or both (cls > 0); default value is 0; see Section 4.2.2.3 for the list of symbols. If cls ≠ 0, subsequent curves on the same frame will cause cls to be incremented by one (decrement by one if cls < 0) for each curve and thus cycle through the available symbols.

14. XDIVISIØNS = xd (Integer > 0)

Applies xd uniform spaces along the x-direction for whichever of the following are called for: UPPER TICS, LØWER TICS, XAXIS; default value is 5 spaces; not applicable to log scales.

15. XVALUE PRINT SKIP = xps (Integer ≥ 0)

Request for values to be placed on x-tic marks. The number of tic marks to be skipped between labeled tic marks is xps; default value is integer zero.

16. CLEAR

Causes all parameter values except PLØTTER and titles (XTITLE, YTITLE, YTTITLE, YBTITLE, TCURVE) to revert to their default values.

17. XTITLE = (any legitimate character string)

Title to be used with x-axis.

18. TCURVE = (any legitimate character string)

Curve title.

The default values for tic divisions on log plots are given in the following table, but will range over whole cycles:

Number of Cycles	Intermediate Values
1, 2	2., 3., 4., 5., 6., 7., 8., 9.
3	2., 3., 5., 7., 9.
4	2., 4., 6., 3.
5	2., 5., 8.
6, 7	3., 6.
8, 9, 10	3.

4.3.2.2 Cards Pertaining Only to Whole Frame Curves

1. YMIN = y1 (Real)
   YMAX = y2 (Real)

   Specifies y1 and y2 as limits of ordinate of curve; default values are chosen so as to accommodate all points.

*See note on page 4.3-8.

2. XAXIS = $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

   Request for plotting x-axis; default value is NØ.

3. YINTERCEPT = yi (Real)

   Location on the y-axis where x-axis is drawn; default value is 0.0.

4. YLØG = $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

   Request for logarithmic y-coordinate; default value is NØ. Default value for tic division interval depends on number of log cycles (see Section 4.3.2.1).

5. LEFT TICS = lt (Integer*)

   Any integer value (lt) causes tic marks to be drawn on the left edge of the frame; default value is integer one.

6. RIGHT TICS = rt (Integer*)

   Any integer value (rt) causes tic marks to be drawn on the right edge of the frame; default value is integer one.

7. ALLEDGE TICS = aet (Integer*)

   Any integer value (aet) causes tic marks to be drawn on all edges of the frame; default value is zero.

8. YDIVISIØNS = yd (Integer > 0)

   Applies yd uniform spaces along the y-direction for whichever of the following are called for: LEFT TICS, RIGHT TICS, YAXIS; default value is 5 spaces; not applicable to log scales.

9. YVALUE PRINT SKIP = yps (Integer $\geq$ 0)

   Request for values to be placed on y-tic marks. The number of tic marks to be skipped between labeled tic marks is yps; default value is integer zero.

10. XGRID LINES = $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

11. YGRID LINES = $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

12. YTITLE = {any legitimate character string}

    Title to be used with y-axis.

* See note on page 4.3-8.

4.3.2.3 Cards Pertaining Only to Upper Half Frame Curves

1. YTMIN = yt1 (Real)
   YTMAX = yt2 (Real)

   Specifies yt1 and yt2 as limits of ordinate of curve; default values are chosen so as to accomodate all points.

2. XTAXIS = $\left\{\begin{matrix}\text{YES}\\ \underline{\text{NØ}}\end{matrix}\right\}$

   Request for plotting x-axis; default value is NØ.

3. YTINTERCEPT = yti (Real)

   Location on the y-axis (yti) where x-axis is drawn; default value is 0.0.

4. YTLØG = $\left\{\begin{matrix}\text{YES}\\ \underline{\text{NØ}}\end{matrix}\right\}$

   Request for logarithmic y-coordinate, default value is NØ. Default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. TLEFT TICS = tlt (Integer*)

   Any integer value (tlt) causes tic marks to be drawn on the left edge of the upper half frame; default value is integer one.

6. TRIGHT TICS = trt (Integer*)

   Any integer value (trt) causes tic marks to be drawn on the right edge of the upper half frame; default value is integer one.

7. TALL EDGE TICS = taet (Integer*)

   Any integer value (taet) causes tic marks to be drawn on all edges of the upper half frame; default value is zero.

8. YTDIVISIØNS = ytd (Integer > 0)

   Applies ytd uniform spaces along the y-direction for whichever of the following are called for: LEFT TICS, RIGHT TICS, YAXIS; default value is 5 spaces; not applicable to log scales.

9. YTVALUE PRINT SKIP = ytps (Integer > 0)

   Request for values to be placed on y-tic marks. The number of tic marks to be skipped between labeled tic marks is ytps.

10. XTGRID LINES = $\left\{\begin{matrix}\text{YES}\\ \underline{\text{NØ}}\end{matrix}\right\}$

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

11. YTGRID LINES = $\left\{\begin{matrix}\text{YES}\\ \underline{\text{NØ}}\end{matrix}\right\}$

    Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

* See note on page 4.3-8.

12. YTTITLE = {any legitimate character string}

    Title to be used with y-axis.

4.3.2.4 Cards Pertaining Only to Lower Half Frame Curves

1. YBMIN = yb1 (Real)
   YBMAX = yb2 (Real)

   Specifies yb1 and yb2 as limits of ordinate of curve; default values are chosen so as to accommodate all points.

2. XBAXIS = {YES / <u>NØ</u>}

   Request for plotting x-axis; default value is NØ.

3. YBINTERCEPT = ybi (Real)

   Location on the y-axis (ybi) where x-axis is drawn; default value is 0.0.

4. YBLØG = {YES / <u>NØ</u>}

   Request for logarithmic y-coordinate, default value is NØ; default value for tic division interval depends on number of log cycles (see table in Section 4.3.2.1).

5. BLEFT TICS - blt (Integer*)

   Any integer value (blt) causes tic marks to be drawn on the left edge of the lower half frame; default value is integer one.

6. BRIGHT TICS = brt (Integer*)

   Any integer value (brt) causes tic marks to be drawn on the right edge of the lower half frame; default value is integer one.

7. BALL EDGE TICS = baet (Integer*)

   Any integer value (baet) causes tic marks to be drawn on all edges of the lower half frame; default value is zero.

8. YBDIVISIØNS = ybd (Integer > 0)

   Applies ybd uniform spaces along the y-direction for whichever of the following are called for: LEFT TICS, RIGHT TICS, YAXIS; default value is 5 spaces; not applicable to log scales.

9. YBVALUE PRINT SKIP = ybps (Integer > 0)

   Request for values to be placed on tic marks. The number of bottom tic marks to be skipped between labeled y-tic marks is ybps; default value is integer zero.

10. XBGRID LINES = {YES / <u>NØ</u>}

    Request for drawing in the grid lines parallel to the x-axis at locations requested for tic marks; default value is NØ.

* See note on page 4.3-8.

11. YBGRID LINES = $\begin{Bmatrix} \text{YES} \\ \underline{\text{NØ}} \end{Bmatrix}$

Request for drawing in the grid lines parallel to the y-axis at locations requested for tic marks; default value is NØ.

12. YBTITLE = any legitimate character string

Title to be used with y-axis.

* Note

To determine if on any given edge (a) tic marks will be drawn without values, (b) no tic marks or values will be drawn or (c) tic marks with values will be drawn, the following sum must be computed by the user. Add the tic integer value of the edge in question to its associated ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS integer value. If the resulting value is less than 0, tic marks will be drawn without values. If the resulting value is 0, no tic marks or values will be drawn. If the resulting value is greater than 0, tic marks with values will be drawn. The user should be "careful" in his use of the ALLEDGE TICS, TALL EDGE TICS, or BALL EDGE TICS cards. For example, the use of only the ALLEDGE TICS = -1 card will result in no tic marks or values being drawn since the default values for individual edges is + 1. Tic values input may only be -1,0, or 1.

4.3.3 Command Operation Cards

When a command operation is encountered, one or more frames will be generated using the current parameter specifications. The form of this card is:

Operation 1 or more (required)	Curve Type 1 only (required)	Plot Type	Subcase List	Curve Request(s)
XYPLØT XYPRINT XYPUNCH XYPEAK XYPAPLØT	ACCE DISP ELFØRCE NØNLINEAR ØLØAD SACCE SDISP SPCF STRESS SVELØ VECTØR VELØ VG	RESPØNSE AUTØ PSDF NA	i_1, i_2, i_3, i_4 THRU i_5, i_6, etc. default is all subcases NA	"frames"

Operation - The entries in the Operation field have the following meaning:

1. XYPLØT - generate X-Y plots for the selected plotter.

2. XYPRINT - generate tabular printer output for the X-Y pairs.

3. XYPUNCH - generate punched card output for the X-Y pairs. Each card contains the following information:

    1. X-Y pair sequence number
    2. X-value
    3. Y-value
    4. Card sequence number

4. XYPEAK - output is limited to the printed summary page for each curve. This summary page contains the maximum and minimum values of y for the range of x.

5. XYPAPLØT - generate X-Y plots within the printed output. This is a capability to provide minimum output for the purpose of observing general curve behavior. Many of the detail specifications available from Section 4.3.2 are not supported. This feature is limited to producing Cartesian plots with titles, overall scales, and data point locations. When the paper is rotated 90° for viewing the paper plots, the X axis moves horizontally along the page and the Y axis moves vertically along the page. Symbol '*' identifies the points associated with the first curve of a frame, then for successive curves on the frame the points are designated by symbols 'O', 'A', 'B', 'C', 'D', 'E', 'F', 'G' and 'H'.

Curve Type - The entries in the curve type field have the meaning given below. Only one may appear in a single command operation logical card. However, there is no limit to the number of such cards.

Curve Type	Meaning
ACCE	Acceleration in the physical set
DISP	Displacement in the physical set
ELFØRCE	Element Force
NØNLINEAR	Nonlinear load
ØLØAD	Load
SACCE	Acceleration in the solution set
SDISP	Displacement in the solution set
SPCF	Single-point force of constraint
STRESS	Element stress
SVELØ	Velocity in the solution set
VECTØR	Displacement in the physical set
VELØ	Velocity in the physical set
VG	Flutter Analysis Curves

Solution set requests are more efficient, as the time-consuming recovery of the dependent displacements can be avoided. If there is a request for STRESS or ELFØRCE, the recovery of dependent displacements cannot be avoided.

Plot Type - The entries in the Plot Type field have the following meanings:

1. RESPØNSE - generate output for static analysis, frequency response, or transient response. This is the default value.
2. AUTØ - generate output for the autocorrelation function.
3. PSDF - generate output for the power spectral density function.

Subcase List - Generate output for the subcase numbers that are listed. Default is all subcases for which solutions were obtained. The subcase list must be in ascending order.

Curve Request(s) - The word "frames" represents a series of curve identifiers of the following general form:

/a1(b1,c1),a2(b2,c2),etc./d1(e1,f1),d2(e2,f2),etc./etc.

The information between slashes (/) specifies curves that are to be drawn on the same frame. The symbol a1 identifies the grid point or element number associated with the first plot on the first frame. The symbol a2 identifies the grid point or element number associated with the second plot on the first frame. The symbols d1 and d2 identify similar items for plots on the second frame, etc. For any particular frame, the symbols must be assigned in order by grid point or element identification number and item code.

The symbols b1 and b2 are codes for the items to be plotted on the upper half of the first frame, and c1 and c2 are codes for the items to be plotted on the lower half of the first frame. If any of the symbols b1, c1, b2, or c2 are missing, the corresponding curve is not generated. If the comma (,) and c1 are absent along with the comma (,) and c2, full frame plots will be prepared on the first frame for the items represented by b1 and b2. For any single frame, curve identifiers must be all of the whole frame type or all of the half frame type, i.e., the comma (,) following b1 and b2 must be present for all entries or absent for all entries in a single frame. The symbols e1, f1, e2, and f2 serve a similar purpose for the second frame, etc. If continuation cards are needed the previous card <u>must</u> be terminated with any one of the slashes (/) or commas (,) in the general format.

The manner in which the item code (e.g., b1, b2) is implemented is dependent upon whether the Plot Type is either (a) RESPØNSE or (b) AUTØ or PSDF.

For VG plots, the a1, a2 refers to the loop count of flutter analysis. The quantities b and c may have the values F for frequency and G for damping.

Plot Type RESPØNSE

For geometric grid points, the item code is one of the mneomonics T1, T2, T3, R1, R2, R3, T1RM, T2RM, T3RM, R1RM, R2RM, R3RM, T1IP, T3IP, R1IP, R2IP, or R3IP, where Ti stands for the i^{th} translational component, Ri stands for the i^{th} rotational component, and RM means real or magnitude and IP means imaginary or phase. For scalar or extra points, use T1, T1RM, or T1IP. For elements use a positive integer from the following tables for element stress item codes or element force item codes. See Section 1.3 for interpretation of symbols.

Plot Types AUTØ or PSDF

For geometric grid points, the item code is one of the mnemonics T1, T2, T3, R1, R2, R3; for scalar or extra points use T1. The symbols T1, T2, T3, R1, R2, R3 are defined as above. For elements use a positive integer from the following tables noting that if an item has a real and imaginary part, the selection of either part will result in the use of both parts. Real numbers will be treated as if they are complex numbers with zero imaginary parts. Split frames cannot be used for AUTØ or PSDF plots.

Element Stress Item Codes

(All items are stresses unless otherwise denoted)

Element Name	Real Element Stresses: Item Code	Real Element Stresses: Item	Complex Element Stresses: Item Code	Complex Element Stresses: Item	Real-Mag. or Imag.-Phase
RØD	2	Axial Stress	2	Axial Stress	RM
	3	Axial Safety Margin	3	Axial Stress	IP
	4	Torsional Stress	4	Torsional Stress	RM
	5	Torsional Safety Margin	5	Torsional Stress	IP
TUBE		Same as RØD		Same as RØD	
SHEAR	2	Maximum Shear	2	Maximum Shear	RM
	3	Average Shear	3	Maximum Shear	IP
	4	Safety Margin	4	Average Shear	RM
			5	Average Shear	IP
TWIST	2	Maximum	2	Maximum	RM
	3	Average	3	Maximum	IP
	4	Safety Margin	4	Average	RM
			5	Average	IP
TRIA1		Z1 = Fibre Distance 1		Z1 = Fibre Distance 1	
	3	Normal-x at Z1	3	Normal-x at 1	RM
	4	Normal-y at Z1	4	Normal-x at 1	IP
	5	Shear-xy at Z1	5	Normal-y at 1	RM
	6	θ-Shear Angle at Z1	6	Normal-y at 1	IP
	7	Major-Principal at Z1	7	Shear-xy at 1	RM
	8	Minor-Principal at Z1	8	Shear-xy at 1	IP
	9	Max-Shear at Z1		Z2 = Fibre Distance 2	
		Z2 = Fibre Distance 2	10	Normal-x at 2	RM
	11	Normal-x at Z2	11	Normal-x at 2	IP
	12	Normal-y at Z2	12	Normal-y at 2	RM
	13	Shear-xy at Z2	13	Normal-y at 2	IP
	14	θ-Shear Angle at Z2	14	Shear-xy at 2	RM
	15	Major-Principal at Z2	15	Shear-xy at 2	IP
	16	Minor-Principal at Z2			
	17	Maximum-Shear at Z2			
TRBSC		Same as TRIA1		Same as TRIA1	
TRPLT		Same as TRIA1		Same as TRIA1	
TRMEM	2	Normal-x	2	Normal-x	RM
	3	Normal-y	3	Normal-x	IP
	4	Shear-xy	4	Normal-y	RM
	5	θ-Shear Angle	5	Normal-y	IP
	6	Major-Principal	6	Shear-xy	RM
	7	Minor-Principal	7	Shear-xy	IP
	8	Maximum Shear			
CØNRØD		Same as RØD		Same as RØD	
ELAS1	2	Stress	2	Stress	RM
			3	Stress	IP
ELAS2	2	Stress	2	Stress	RM
			3	Stress	IP

X-Y OUTPUT

Element Name	Item Code	Real Element Stresses: Item	Item Code	Complex Element Stresses: Item	Real-Mag. or Imag.-Phase
ELAS3	2	Stress	2	Stress	RM
			3	Stress	IP
QDPLT		Same as TRIA1		Same as TRIA1	
QDMEM		Same as TRMEM		Same as TRMEM	
QDMEM1		Same as TRMEM		Same as TRMEM	
QDMEM2		Same as TRMEM		Same as TRMEM	
TRIA2		Same as TRIA1		Same as TRIA1	
QUAD2		Same as TRIA1		Same as TRIA1	
QUAD1		Same as TRIA1		Same as TRIA1	
BAR	2	SA1	2	SA1	RM
	3	SA2 *	3	SA2 *	RM
	4	SA3	4	SA3	RM
	5	SA4	5	SA4	RM
	6	Axial	6	Axial	RM
	7	SA-maximum	7	SA1	IP
	8	SA-minimum	8	SA2 *	IP
	9	Safety Margin in Tension	9	SA3	IP
	10	SB1	10	SA4	IP
	11	SB2 *	11	Axial	IP
	12	SB3	12	SB1	RM
	13	SB4	13	SB2	RM
	14	SB-maximum	14	SB3	RM
	15	SB-minimum	15	SB4 *	RM
	16	Safety Margin in Comp.	16	SB1	IP
			17	SB2	IP
			18	SB3	IP
			19	SB4	IP
CØNEAX		Z1 = Fibre Distance 1			
	4	Normal-u at 1			
	5	Normal-v at 1			
	6	Shear-uv at 1			
	7	θ-Shear Angle at 1			
	8	Major-Principal at 1			
	9	Minor-Principal at 1			
	10	Maximum Shear at 1			
		Z2 = Fibre Distance 2			
	12	Normal-u at 2			
	13	Normal-v at 2			
	14	Shear-uv at 2			
	15	θ-Shear Angle at 2			
	16	Major-Principal at 2			
	17	Minor-Principal at 2			
	18	Maximum Shear at 2			
TRIARG	2	Radial (x)			
	3	Circum. (Theta)			
	4	Axial (z)			
	5	Shear (zx)			

*See footnote at the end of this table.

Element Name	Item Code	Real Element Stresses Item		Item Code	Complex Element Stresses Item	Real-Mag. or Imag.-Phase
TRAPRG	2	Radial (x)	at 1			
	3	Circum. (Theta)	at 1			
	4	Axial (z)	at 1			
	5	Shear (zx)	at 1			
	6	Radial (x)	at 2			
	7	Circum. (Theta)	at 2			
	8	Axial (z)	at 2			
	9	Shear (zx)	at 2			
	10	Radial (x)	at 3			
	11	Circum. (Theta)	at 3			
	12	Axial (z)	at 3			
	13	Shear (zx)	at 3			
	14	Radial (x)	at 4			
	15	Circum. (Theta)	at 4			
	16	Axial (z)	at 4			
	17	Shear (zx)	at 4			
	18	Radial (x)	at 5			
	19	Circum. (Theta)	at 5			
	20	Axial (z)	at 5			
	21	Shear (zx)	at 5			
TØRDRG	2	Mem.-Tangen.	at 1			
	3	Mem.-Circum.	at 1			
	4	Flex.-Tangen.	at 1			
	5	Flex.-Circum.	at 1			
	6	Shear-Force	at 1			
	7	Mem.-Tangen.	at 2			
	8	Mem.-Circum.	at 2			
	9	Flex.-Tangen.	at 2			
	10	Flex.-Circum.	at 2			
	11	Shear-Force	at 2			
	12	Mem.-Tangen.	at 3			
	13	Mem.-Circum.	at 3			
	14	Flex.-Tangen.	at 3			
	15	Flex.-Circum.	at 3			
	16	Shear-Force	at 3			
TETRA	2	Normal (x)		2	Normal (x)	RM
	3	Normal (y)		3	Normal (y)	RM
	4	Normal (z)		4	Normal (z)	RM
	5	Shear (yz)		5	Shear (yz)	RM
	6	Shear (xy)		6	Shear (xy)	RM
	7	Shear (xz)		7	Shear (xz)	RM
	8	Octahedral		8	Normal (x)	IP
	9	Pressure		9	Normal (y)	IP
				10	Normal (z)	IP
				11	Shear (yz)	IP
				12	Shear (xy)	IP
				13	Shear (xz)	IP
WEDGE	Same as TETRA			Same as TETRA		
HEXA1	Same as TETRA			Same as TETRA		
HEXA2	Same as TETRA			Same as TETRA		

4.3.4 Examples of X-Y Output Request Packets

BEGIN BULK or ØUTPUT(PLØT) card is shown as a reminder to the user to place his X-Y output request packet properly in his Case Control Deck, i.e., at the end of the Case Control Deck or just ahead of any structure plot requests. The user must ensure that file PLT2 is set up for plotting use via system control cards to use a tape or mass storage area.

Example 1

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
XYPLØT SDISP / 16(T1)
BEGIN BULK
```

Causes a single whole frame to be plotted for the T1 displacement component of solution set point 16 using the default parameter values. If 16(T1) is not in the solution set, a warning message will be printed and no plot will be made. The plot will be generated for the SC 4020 plotter.

Example 2

```
ØUTPUT(XYØUT)
PLØTTER = CALCØMP 5651,751
XYPLØT, XYPRINT VELØ RESPØNSE 1,5 / 3(R1, ), 5( ,R1)
ØUTPUT(PLØT)
```

Causes a single frame (consisting of an upper half frame and a lower half frame) to be plotted using the default parameter values. The velocity of the first rotational component of grid point 3 will be plotted on the upper half frame and that of grid point 5 will be plotted on the lower half frame for subcases 1 and 5. Tabular printer output will also be generated for both curves. The plots will be generated for the CALCØMP 565 plotter. Scales will be selected such that the frame will fit on 12 x 11-inch paper.

Example 3

```
ØUTPUT(XYPLØT)
PLØTTER = SC 4020
YDIVISIØNS = 20
XDIVISIØNS = 10
XGRID LINES = YES
YGRID LINES = YES
XYPLØT DISP 2,5 /10(T1),10(T3)
```

Causes two whole frame plots to be generated, one for subcase 2 and one for subcase 5. Each

plot contains the T1 and T3 displacement component for grid point 10. The default parameters will be modified to include grid lines in both the x and y-directions with 10 spaces in the x-direction and 20 spaces in the y-direction. The plot will be generated for the SC 4020 plotter.

Example 4

```
ØUTPUT(XYPLØT)
PLØTTER = CALCØMP 7631,772
XAXIS = YES
YAXIS = YES
XPAPER = 17.0
YPAPER = 22.0
XYPLØT STRESS 3/ 15(2)/ 21(6)
```

Causes two whole frame plots to be generated using the results from subcase 3. The first plot is the response of the axial stress for rod element number 15. The second plot is the response of the major principal stress for triangular membrane element number 21. The default parameters will be modified to include the x-axis and y-axis drawn through the origin. Each plot will be scaled to fit on 30 x 29-inch paper. The plots will be generated for the CALCØMP 763 plotter.

Example 5

```
ØUTPUT (XYPLØT)
PLØTTER = NASTPLT D,0
CURVELINESYMBØL = -1
XYPLØT VG / 1(G,F) 2(G,F) 3(G,F) 4(G,F)
```

A split frame plot will be made; the upper half is V-g and the lower half is V-f. Data from the first four loops will be plotted. Distinct symbols are used for data from each loop, and no lines are drawn between points (since the flutter analyst must sometimes exercise judgement about which points should be connected).

5. DIRECT MATRIX ABSTRACTION

5.1 GENERAL

In addition to using the rigid formats provided automatically by NASTRAN, the user may wish to execute a series of modules in a different manner than provided by the rigid format. Or, he may wish to perform a series of matrix operations which are not contained in any existing rigid format. If the modifications to an existing rigid format are minor, the ALTER feature described in Section 2 may be employed. Otherwise, a user-written Direct Matrix Abstraction Program (DMAP) should be used.

DMAP is the user-oriented language used by NASTRAN to solve problems. A rigid format is basically a collection of statements in this language. DMAP, like English or FØRTRAN, has many grammatical rules which must be followed to be interpretable by the NASTRAN DMAP compiler. Section 5.2 provides the user with the rules of DMAP which will allow him to understand the rigid format DMAP sequences, write ALTER packages, and construct his own DMAP sequences using the many modules contained in the NASTRAN DMAP repertoire.

Section 5.3 is an index of matrix, utility, user and executive DMAP modules which are contained in Sections 5.4 thru 5.7 respectively.

Sections 5.4 thru 5.7 describe individually the many nonstructurally oriented modules contained in the NASTRAN library. Section 5.8 provides several examples of DMAP usage.

User-written modules must conform to the rules and usage conventions described herein.

5.2 DMAP RULES

Grammatically, DMAP instructions consist of two types: Executive Operation Instructions and Functional Module Instructions. Grammatical rules for these two types of instructions will be discussed separately in subsequent sections.

Functional modules are arbitrarily classified as structural modules, matrix operation modules, utility modules, or user-generated modules.

The DMAP sequence itself consists of a series of DMAP instructions or statements, the first of which is BEGIN or XDMAP and the last of which is END. The remaining statements consist of Executive Operation instructions and Functional Module calls.

5.2.1 DMAP Rules for Functional Module Instructions

The primary characteristic of the Functional Module DMAP instruction is its prescribed format. The general form of the Functional Module DMAP statement is:

```
MØD   I1,I2,---,Im/Ø1,Ø2,---,Øn/a1,b1,p1/a2,b2,p2----/az,bz,pz  $

   where   MØD is the DMAP Functional Module name,
           Ii; i = 1,m are the Input Data Block names,
           Øi; i = 1,n are the Øutput Data Block names,
   and     ai,bi,pi; i = 1,z are the Parameter Sections.
```

In the general form shown above, commas (,) are used to separate several like items while slashes (/) are used to separate sections from one another. The module name is separated from the rest of the instruction by a blank or a comma (,). The dollar sign ($) is used to end the instruction and is not required unless the instruction ends in the delimiter / . Blanks may be used in conjunction with any of the above delimiters for ease of reading.

A functional module communicates with other modules and the executive system entirely through its inputs, outputs and parameters. The characteristics or attributes of each functional module are contained in the Module Properties List (MPL) described in Section 2.4 of the Programmer's Manual and are reflected in the DMAP Module Descriptions that follow in Section 5.3 and in the Module Functional Descriptions contained in Chapter 4 of the Programmer's Manual. The module name is a BCD value (which consists of an alphabetic character followed by up to seven additional alphanumeric characters) and must correspond to an entry in the MPL. A Data Block name may be either a BCD value or null. The absence of a BCD value indicates that the Data Block is not needed for a particular application.

5.2.1.1 Functional Module DMAP Statements

Each Functional Module DMAP statement must conform to the MPL regarding:

1. Name spelling
2. Number of input data blocks
3. Number of output data blocks
4. Number of parameters
5. Type of each parameter

Note: See Sections 5.2.1.3 and 5.2.1.4 for allowable exceptions to these rules.

5.2.1.2 Functional Module Names

The only Functional Module DMAP names allowed are those contained in the MPL. Therefore, if a user wishes to add a module, he must either use one of the User Module names provided (see Section 5.6) or add a name to the MPL. The Programmer's Manual should be consulted when adding a new module to NASTRAN.

5.2.1.3 Functional Module Input Data Blocks

In most cases an input data block should have been previously defined in a DMAP program before it is used. However, there may be instances in which a module can handle, or may even expect, a data block to be undefined at the time the module is initially called. An input data block is previously defined if it appears as an output data block in a previous DMAP instruction, as output from the Input File Processor, any user-input (via Bulk Data Cards) DMI or DTI data block name, or exists on the Old Problem Tape in a restart problem. Although the number of data blocks is prescribed, if any number of final data blocks are null, they may be omitted from the section. For example, the module TABPT, which uses five input data blocks, may be defined by:

```
TABPT   GEØM1,,,, // $
```

or

```
TABPT   GEØM1 // $
```

A potentially fatal error message (See Section 5.2.1.7) will be issued at compilation time to warn the user that a discrepancy in the data block name list has been detected. This is also true in the event that a previously undefined data block is used as input. Also, see the "error-level" option on the XDMAP compiler option card which may be invoked by the user to terminate execution in the event of such errors.

The new DMAP user should read Sections 5.4 through 5.7 to obtain the necessary knowledge of terminology before reading this section.

The data blocks and functional modules referenced in the following examples are fictitious and have no relationship to any real data blocks or functional modules.

A data block is described as having a status of "not generated," "generated" or "purged." A status of not generated means that the data blocks is available for generation by appearing as output in a functional module. A status of generated means that the data block contains data which is available for input to a subsequent module. A status of purged means that the data block cannot be generated and any functional module attempting to use this data block as input or output will be informed that the purged data block is not available for use.

5.2.3.1 The REPT and FILE Instructions (see Section 5.7)

The DMAP instructions bounded by the REPT instruction and the label referenced by the REPT instruction are referred to as a loop. The location referenced by the REPT is called the top of the loop. In many respects a DMAP loop is like a giant functional module since it requires inputs and generates output data blocks which usually can be handled correctly by the File Allocator (see Section 4.9 of the Programmer's Manual) without any special action by the DMAP programmer. The one exception is a data block that is not referenced outside the loop (i.e., an internal data block with respect to the loop). The file allocator considers internal data blocks as scratch data blocks to be used for the present pass through the loop but not to be saved for input at the top of the loop. Should the DMAP programmer desire to save an internal data block, he may do so by declaring the data block SAVE in the FILE instruction.

When the REPT instruction transfers control back to the top of the loop, the status of all internal data blocks is changed to "not generated" unless the internal data block is declared SAVE or APPEND in a FILE instruction. It should also be noted that equivalences established between internal data blocks (not declared saved) and data blocks referenced outside the loop are not carried over for the next time through the loop. The equivalence must be re-established each time through the loop. Data blocks generated by the Input File Processor are considered referenced outside of all DMAP loops.

EXAMPLE using REPT and FILE instructions.

```
          BEGIN     $
          FILE      X=SAVE / Y=APPEND / Z=APPEND $
          LABEL     L1 $
          MØD1      B/W,Y $
          CØND      L3,PX $
DMAP      MØD2      A/X/V,N,PX=0 $
loop      SAVE      PX $
          LABEL     L3 $
          MØD3      W,X,Y/Z $
          REPT      L1,1 $
          MØD4      Z// $
          END       $
```

Assume that MØD2 sets PX < 0 when it is executed. Note that Z is declared APPEND, whereas Y will be saved since it is an internal data block that is to be appended. X is an internal data block that is to be saved since it will only be generated the first time through the loop but is needed as input each time the loop is repeated. W is an internal data block that is generated each time through the loop; therefore, it is not saved.

The following table shows what happens when the above DMAP program is executed. Only modules being executed are shown in the table. Data blocks A and B are assumed to be generated by the Input File Processor, and hence are considered referenced outside of all DMAP loops.

5.3 INDEX OF DMAP MODULE DESCRIPTIONS

Descriptions of all nonstructurally oriented Modules are contained herein, arranged alphabetically by category as indicated by the lists below. Descriptions for the structurally oriented modules are contained in Section 4 of the Programmer's Manual. They are listed here in order to provide a complete list of all NASTRAN Modules. Additional information regarding nonstructurally oriented modules is also given in Section 4 of the Programmer's Manual.

<u>Matrix Operation Modules</u> (13)
(See Section 5.4)

ADD	SDCMPS
ADD5	SMPYAD
DECØMP	SØLVE
FBS	TRNSP
MERGE	UMERGE
MPYAD	UPARTN
PARTN	

<u>Utility Modules</u> (26)
(See Section 5.5)

CØPY	PARAML
DIAGØNAL	PARAMR
INPUT	PRTPARM
INPUTT1	PVEC
INPUTT2	SCALAR
LAMX	SEEMAT
MATGPR	SETVAL
MATPRN	SWITCH
MATPRT	TABPCH
ØUTPUT1	TABPRT
ØUTPUT2	TABPT
ØUTPUT3	TIMETEST
PARAM	VEC

<u>User Modules</u> (14)
(See Section 5.6)

DDR	MØDA
DUMMØD1	MØDB
DUMMØD2	MØDC
DUMMØD3	ØUTPUT
DUMMØD4	ØUTPUT4
INPUTT3	PARTVEC
INPUTT4	XYPRNPLT

<u>Executive Operation Modules</u> (14)
(See Section 5.7)

BEGIN	JUMP
CHKPNT	LABEL
CØND	PRECHK
END	PURGE
EQUIV	REPT
EXIT	SAVE
FILE	XDMAP

<u>Substructure DMAP ALTERs</u> (19)
(See Section 5.9)

BRECØVER	REDUCE
CHECK	RENAME
CØMBINE	RESTØRE
DELETE	RUN
DESTRØY	SØFIN
DUMP	SØFØUT
EDIT	SØFPRINT
EQUIV	SØLV
PLØT	SUBSTRUCTURE
RECØVER	

<u>Supplementary Functional Modules</u> (2)
(See Section 5.10)

EQMCK	GPSPC

DIRECT MATRIX ABSTRACTION

In the examples that accompany each description, the following notation is used:

1. Upper case letters and special symbols in the DMAP calling sequence must be punched as shown except for data block names, parameter names, and label names which are symbolic.
2. Lower case letters represent constants whose permissible values are indicated in the descriptive text.

Due to the many possible forms which may be used when writing parameters, a variety of arbitrarily selected forms will be used in the examples. This does not imply that the form used in any example is required or that it is the only acceptable form allowed.

The terms form, type, and precision are used in many functional module descriptions. By form is meant one of the following:

Form	Meaning
1	Square
2	Rectangular
6	Symmetric

By type is meant one of the following:

Type	Meaning
1	Real, single precision
2	Real, double precision
3	Complex, single precision
4	Complex, double precision

By precision is meant one of the following:

Precision Indicator	Meaning
1	Single precision numbers
2	Double precision numbers

INDEX OF DMAP MODULE DESCRIPTIONS

Major Functional Modules (79)
(See Section 4 of the Programmer's Manual)

ADR	FRRD	ØPTPR1	SDR3
AMG	FRRD2	ØPTPR2	SDRHT
AMP	GI	PLA1	SMA1
APD	GKAD	PLA2	SMA2
BMG	GKAM	PLA3	SMA3
CASE	GPCYC	PLA4	SMP1
CEAD	GPFDR	PLØT	SMP2
DDR1	GP1	PLTSET	SSGHT
DDR2	GP2	PLTTRAN	SSG1
DDRMM	GP3	PRTMSG	SSG2
DPD	GP4	RANDØM	SSG3
DSCHK	GPSP	RBMG1	SSG4
DSMG1	GPSPC	RBMG2	TA1
DSMG2	GPWG	RBMG3	TRD
EMA	GUST	RBMG4	TRHT
EMG	IFT	READ	TRLG
EQMCK	MCE1	RMG	VDR
FA1	MCE2	SCE1	XYPLØT
FA2	MTRXIN	SDR1	XYTRAN
FRLG	ØFP	SDR2	

5.4 MATRIX OPERATIONS MODULES

Module	Basic Operation	Page
ADD	$[X] = a[A] + b[B]$	5.4-2
ADD5	$[X] = a[A] + b[B] + c[C] + d[D] + e[E]$	5.4-3
DECØMP	$[A] \Rightarrow [L][U]$	5.4-4
FBS	$[X] = ([L][U])^{-1}\,[B]$	5.4-5
MERGE	$[A] \Leftarrow \left[\begin{array}{c:c} A11 & A12 \\ \hdashline A21 & A22 \end{array}\right]$	5.4-7
MPYAD	$[X] = [A][B] + [C]$	5.4-9
PARTN	$[A] \Rightarrow \left[\begin{array}{c:c} A11 & A12 \\ \hdashline A21 & A22 \end{array}\right]$	5.4-11
SDCMPS	$[A] \Rightarrow [L][U]$	5.4-13a
SMPYAD	$[X] = [A][B][C][D][E] + [F]$	5.4-14
SØLVE	$[X] = [A]^{-1}\,[B]$	5.4-16
TRNSP	$[X] = [A]^{T}$	5.4-18
UMERGE	$\left\{ PHIF \right\} \Leftarrow \left\{ \begin{array}{c} PHIA \\ \hline PHI\emptyset \end{array} \right\}$	5.4-19
UPARTN	$[K_{ii}] = \left[\begin{array}{c\|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$	5.4-20

DIRECT MATRIX ABSTRACTION

I. NAME: ADD (Matrix Add)

II. PURPØSE: To compute [X] = a[A] + b[B] where a and b are scale factors.

III. DMAP CALLING SEQUENCE:

ADD A,B / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) $

IV. INPUT DATA BLØCKS:

A - Any matrix

B - Any matrix

Note: [A] and/or [B] may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. ØUTPUT DATA BLØCKS:

X - matrix.

The type of [X] is maximum of the types of [A], [B], a, b. The size of [X] is the size of [A] if [A] is present. Otherwise it is that of [B].

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

Note: If Im(ALPHA) or Im(BETA) = 0.0 the corresponding parameter will be considered real.

I. NAME: ADD5 (Matrix Add)

II. PURPOSE: To compute [X] = a[A] + b[B] + c[C] + d[D] + e[E] where a, b, c, d and e are scale factors.

III. DMAP CALLING SEQUENCE:

```
ADD5  A,B,C,D,E / X / C,Y,ALPHA=(1.0,2.0) / C,Y,BETA=(3.0,4.0) / C,Y,GAMMA=(5.0,6.0) /
                      C,Y,DELTA=(7.0,8.0) / C,Y,EPSLN=(9.0,1.0) $
```

IV. INPUT DATA BLOCKS:

A, B, C, D, and E must be distinct matrices.

Note: Any of the matrices may be purged, in which case the corresponding term in the matrix sum will be assumed null. The input data blocks must be unique.

V. OUTPUT DATA BLOCKS:

X - matrix.

The type of [X] is maximum of the types of A, B, C, D, E, a, b, c, d, e. The size of [X] is the size of the first nonpurged input.

Note: [X] cannot be purged.

VI. PARAMETERS:

ALPHA - Input-complex-single precision, default = (1.0, 0.0). This is a, the scalar multiplier for [A].

BETA - Input-complex-single precision, default = (1.0, 0.0). This is b, the scalar multiplier for [B].

GAMMA - Input-complex-single precision, default = (1.0, 0.0). This is c, the scalar multiplier for [C].

DELTA - Input-complex-single precision, default = (1.0, 0.0). This is d, the scalar multiplier for [D].

EPSLN - Input-complex-single precision, default = (1.0, 0.0). This is e, the scalar multiplier for [E].

Note: If Im(ALPHA), Im(BETA), Im(GAMMA), Im(DELTA), or Im(EPSLN) = 0.0, the corresponding parameter will be considered real.

I. DECØMP (Matrix Decomposition)

II. PURPØSE: To decompose a square matrix [A] into upper and lower triangular factors [U] and [L] .

[A] => [L][U]

III. DMAP CALLING SEQUENCE:

DECØMP A / L,U / V,Y,KSYM / V,Y,CHØLSKY / V,N,MINDIAG / V,N,DET / V,N,PØWER / V,N,SING $

IV. INPUT DATA BLØCKS:

A - A square matrix

V. ØUTPUT DATA BLØCKS:

L - Nonstandard lower triangular factor of [A].

U - Nonstandard upper triangular factor of [A].

VI. PARAMETERS:

KSYM - Input-integer, default = 0. 1, use symmetric decomposition. 0, use unsymmetric decomposition.

CHØLSKY - Input-integer, default = 0. 1, use Cholesky decomposition - matrix must be positive definite. 0, do not use Cholesky decomposition.

MINDIAG - Output-real double precision, default = 0.0D0. The minimum diagonal term of [U].

DET - Output-complex single precision, default = 0.0D0. The scaled value of the determinant of [A].

PØWER - Output-integer, default = 0. Integer PØWER of 10 by which DET should be multiplied to obtain the determinant of [A].

SING - Output-integer, default = 0. SING is set to -1 if [A] is singular.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process in module FBS. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. The matrix manipulating utility modules should be cautiously employed when dealing with non-standard matrix data blocks.

3. If the CHØLSKY option is selected, the resulting factor (which will be written as [U]) cannot be input to FBS.

4. Variable parameters output from functional modules must be SAVEd if they are to be subsequently used. See the Executive Module SAVE description.

I. NAME: MPYAD (Matrix Multiply and Add)

II. PURPOSE: MPYAD performs the multiplication of two matrices and, optionally, addition of a third matrix to the product. By means of parameters, the user may compute $\pm [A][B] \pm [C] = [X]$, or $\pm [A]^T[B] \pm [C] = [X]$.

III. DMAP CALLING SEQUENCE:

```
MPYAD   A,B,C / X / V,N,T / V,N,SIGNAB / V,N,SIGNC / V,N,TYPEX $
```

IV. INPUT DATA BLOCKS:

A - Left hand matrix in the matrix product [A][B]

B - Right hand matrix in the matrix product [A][B]

C - Matrix to be added to [A][B]

Notes:

1. If no matrix is to be added, [C] must be purged.
2. [A], [B], [C] must be physically different data blocks.
3. [A] and [B] must not be purged.
4. [A], [B], and [C] must be conformable. This condition is checked by MPYAD.

V. OUTPUT DATA BLOCKS:

X - Matrix resulting from the MPYAD operation.

Note: [X] may not be purged.

VI. PARAMETERS:

T - Integer-input, no default. $T = \begin{cases} 1 - \text{perform } [A]^T[B] \\ 0 - \text{perform } [A][B] \end{cases}$

SIGNAB - Integer-input, default = 1. $SIGNAB = \begin{cases} +1 - \text{perform } [A][B] \\ 0 - \text{omit } [A][B] \\ -1 - \text{perform } [A][B] \end{cases}$

SIGNC - Integer-input, default = 1. $SIGNC = \begin{cases} +1 - \text{add } [C] \\ 0 - \text{omit } [C] \\ -1 - \text{subtract } [C] \end{cases}$

TYPEX - Input-integer, default = 0.
- 0 - logical choice based on input
- 1 - output type of matrix X is real single precision
- 2 - output type of matrix X is real double precision
- 3 - output type of matrix X is complex single precision
- 4 - output type of matrix X is complex double precision

- Output-integer TYPEX used.

VII. **EXAMPLES:**

1. [X] = [A][B]+[C] ([X] see notes)
   MPYAD A,B,C / X / C,N,0 $

2. [X] = $[A]^T$[B]-[C] ([X] real single-precision)
   MPYAD A,B,C / X / C,N,1 / C,N,1 / C,N,-1 / C,N,1 $

3. [X] = -[A][B] ([X] see notes)
   MPYAD A,B, / X / C,N,0 / C,N,-1 $

Notes: The precision of [X] is determined from the input matrices in that if anyone of these matrices is specified as double precision, then [X] will also be double precision. If the precision for the input matrices is not specified, the precision of the system flag will be used.

I. NAME: PARTN (Matrix Partition)

II. PURPØSE: To partition [A] into [A11], [A12], [A21] and [A22]:

$$[A] \Longrightarrow \begin{array}{c|c} & \overset{\longleftarrow \; CP \; \longrightarrow}{} \\ \hline RP & \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right] \begin{array}{l} = 0 \\ \neq 0 \end{array} \\ & \;\; = 0 \quad\; \neq 0 \end{array}$$

III. DMAP CALLING SEQUENCE:

PARTN A,CP,RP / A11,A21,A12,A22 / V,Y,SYM / V,Y,TYPE / V,Y,F11 / V,Y,F21 / V,Y,F12 / V,Y,F22 $

IV. INPUT DATA BLØCKS:

A - Matrix to be partitioned.

CP - Column partitioning vector - single precision column vector.

RP - Row partitioning vector - single precision column vector.

V. ØUTPUT DATA BLØCKS:

A11 - Upper left partition of [A]

A21 - Lower left partition of [A]

A12 - Upper right partition of [A]

A22 - Lower right partition of [A]

Notes: 1. Any or all output data blocks may be purged.
2. For size of outputs see METHØD section below.

VI. PARAMETERS:

SYM - Input-integer, default = -1. SYM chooses between a symmetric partition and one unsymmetric partition. If SYM < 0, {CP} is used as {RP}. If SYM $\geq$ 0, {CP} and {RP} are distinct.

TYPE - Input-integer, default = 0. Type of output matrices - see Remark 8

F11 - Input-integer, default = 0. Form of [A11].

F21 - Input-integer, default = 0. Form of [A21].

F12 - Input-integer, default = 0. Form of [A12].

F22 - Input-integer, default = 0. Form of [A22].

(F11–F22: See Remark 7)

VII. METHØD:

Let NC = number of nonzero terms in {CP}.

Let NR = number of nonzero terms in {RP}.

Let NRØWA = number of rows in [A].

Let NCØLA = number of columns in [A].

Case 1 {CP} purged and SYM $\geq$ 0.

[A11] is a (NRØWA-NR) by NCØLA matrix.

[A21] is a NR by NCØLA matrix.

[A12] is not written.

[A22] is not written.

$$[A] \rightarrow \left[\begin{array}{c} A11 \\ \hline A21 \end{array}\right]$$

CASE 2 {RP} purged and SYM $\geq$ 0

[A11] is a NRØWA by (NCØLA - NC) matrix.

[A21] is not written.

[A12] is a NRØWA by NC matrix.

[A22] is not written.

$$[A] \rightarrow [A11 \mid A12]$$

CASE 3 SYM < 0 ({RP} must be purged)

[A11] is a (NRØWA - NC) by (NCØLA - NC) matrix.

[A21] is a NC by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NC) by NC matrix.

[A22] is a NC by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

CASE 4 neither {CP} nor {RP} purged and SYM $\geq$ 0

[A11] is a (NRØWA - NR) by (NCØLA - NC) matrix.

[A21] is a NR by (NCØLA - NC) matrix.

[A12] is a (NRØWA - NR) by NC matrix.

[A22] is a NR by NC matrix.

$$[A] \rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

VIII. REMARKS:

1. If [A] is purged, PARTN will cause all output data blocks to be purged.
2. If {CP} is purged, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c} A11 \\ \hline A21 \end{array}\right].$$

3. If {RP} is purged and SYM $\geq$ 0, [A] is partitioned as follows:

$$[A] \Rightarrow [A11 \mid A12]$$

4. If {RP} is purged and SYM < 0, [A] is partitioned as follows:

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right].$$

   where {CP} is used as both the row and column partitioner.
5. {RP} and {CP} cannot both be purged.
6.

$$[A] \Rightarrow \left[\begin{array}{c|c} A11 & A12 \\ \hline A21 & A22 \end{array}\right]$$

   Let [A] be a m by n order matrix.

   Let {CP} be a n order column vector containing q zero elements.

   Let {RP} be a m order column vector containing p zero element.

   Partition [A11] will consist of all elements A_{ij} of [A] for which $CP_j = RP_i = 0$ in the same order as they appear in [A].

   Partition [A12] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i = 0$ in the same order as they appear in [A].

Partition [A21] will consist of all elements A_{ij} or [A] for which $CP_j = 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

Partition [A22] will consist of all elements A_{ij} of [A] for which $CP_j \neq 0$ and $RP_i \neq 0$ in the same order as they appear in [A].

7. If the defaults for F11, F21, F12 or F22 are used, the corresponding matrix will be output with a compatible form entered in the trailer.

8. If TYPE = 0, the type of the output matrices will be the type of the input matrix [A].

IX. EXAMPLES:

1. Let [A], {CP} and {RP} be defined as follows:

$$[A] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \\ 9.0 & 10.0 & 11.0 & 12.0 \end{bmatrix}, \quad \{CP\} = \begin{Bmatrix} 1.0 \\ 0.0 \\ 1.0 \\ 1.0 \end{Bmatrix}, \quad \{RP\} = \begin{Bmatrix} 0.0 \\ 0.0 \\ 1.0 \end{Bmatrix}$$

Then, the DMAP instruction

PARTN A,CP,RP / A11,A21,A12,A22 / C,N,1 $

will create the real double precision matrices

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \end{bmatrix}, \ F11 = 2 \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \end{bmatrix}, \ F12 = 2$$

$$[A21] = [10.0], \ F21 = 1 \qquad [A22] = [9.0 \quad 11.0 \quad 12.0], \ F22 = 2$$

2. If, in Example 1, the DMAP instruction were written as

PARTN A,CP, / A11,A21,A12,A22 / C,N,1 $

the resulting matrices would be

$$[A11] = \begin{bmatrix} 2.0 \\ 6.0 \\ 10.0 \end{bmatrix} \qquad [A12] = \begin{bmatrix} 1.0 & 3.0 & 4.0 \\ 5.0 & 7.0 & 8.0 \\ 9.0 & 11.0 & 12.0 \end{bmatrix}$$

[A21] = purged [A22] = purged

3. If, in Example 1, the DMAP instruction were written as

PARTN A,,RP / A11,A21,A12,A22 / C,N,1 $

the resulting matrices would be

$$[A11] = \begin{bmatrix} 1.0 & 2.0 & 3.0 & 4.0 \\ 5.0 & 6.0 & 7.0 & 8.0 \end{bmatrix} \qquad [A12] = \text{purged}$$

$$[A21] = [9.0 \quad 10.0 \quad 11.0 \quad 12.0] \qquad [A22] = \text{purged}$$

I. NAME: SDCMPS (Symmetric Decomposition)

II. PURPOSE: To decompose a matrix [A] into upper and lower triangular factors [U] and [L].

$$[A] \Rightarrow [L][U] .$$

Badly conditioned matrix columns for symmetric real matrices are identified in external identification numbers. Various user exit controls for error conditions are available.

III. DMAP CALLING SEQUENCE:

```
SDCMPS  USET,GPL,SIL,A / L,U / V,Y,SYM / V,Y,DIAGCK / V,Y,DIAGET / V,Y,PDEFCK / V,N,SING /
                         V,Y,SET / V,Y,CHØLSKY / V,N,DET / V,N,MINDIA / V,N,PØWER /
                         V,Y,SUBNAM $
```

IV. INPUT DATA BLOCKS:

USET - Displacement Set Definition Table

GPL - Grid Point List

SIL - Scalar Index List

A - A real symmetric matrix (may not be purged)

Note: Error conditions will be identified by column number if USET, GPL, or SIL are purged for non-substructuring problems.

V. OUTPUT DATA BLOCKS:

L - Lower triangular factor of [A]

U - Upper triangular factor of [A]

VI. PARAMETERS:

SYM - Input, integer, default = 0. 1, use symmetric decomposition. -1, use unsymmetric decomposition. 0, use decomposition based on input matrix form.

DIAGCK - Input, integer, default = 0. Diagonal singularity or nonconservative column exit flag.

- = 0 - nonfatal messages for $e_s > T_s$ (see DIAGET and Remark 6 for definitions).
- > 0 - a maximum of DIAGCK messages for $e_s > T_s$ before aborting decomposition prior to completion.
- < 0 - no check of e_s.

DIAGET - Input, integer, default = 20. Diagonal singularity error tolerance. Used in conjunction with DIAGCK. A message is issued if the error, $e_s > T_s = 2^{-n}$, where n = DIAGET.

PDEFCK - Input, integer, default = 0. Positive definite exit flag.

- = 0 - nonfatal messages are issued for $D_{ii} < 0.0$ and fatal messages are issued for $D_{ii} = 0.0$.
- > 0 - a maximum of PDEFCK fatal messages for all $D_{ii} \leq 0.0$ are issued before aborting decomposition prior to completion.
- < 0 - no check for $D_{ii} < 0.0$. If $D_{ii} = 0.0$, absolute value of PDEFCK messages are issued before aborting deocmposition prior to completion.

SING - Output, integer, no default. SING is set to -1 if [A] is singular, 0 if not positive definite, and 1 otherwise, in the given order.

SET# - Input, BCD, default = L. The displacement set to which [A] belongs.

CHØLSKY - Input, integer, default = 0. Cholesky decomposition is used if the value is 1 (matrix must be positive definite); Cholesky decomposition is not used for values other than 1.

DET - Output, real single precision, default = 0.0. The scaled value of the determinant of [A].

MINDIA - Output, double precision, default = 0.0D0. Minimum diagonal of [U].

PØWER - Output, integer, default = 0. Integer power of 10 by which DET should be multiplied to obtain the determinant of [A].

SUBNAM - Input, BCD, default = NØNE. Name of substructure being solved. Not necessary unless this is a substructuring problem.

VII. REMARKS:

1. Non-standard triangular factor matrix data blocks are used to improve the efficiency of the back substitution process in module FBS. The format of these data blocks is given in Section 2 of the Programmer's Manual.

2. If the CHØLSKY option is selected, the resulting factor (which will be written as [U]) cannot be input to FBS.

3. Upon finding a zero diagonal (D_{ii}) on the decomposed matrix a value of 1.0 is substituted for the diagonal term if decomposition is to proceed. However, the fatal error flag is always set in this case.

4. All zero columns on the input matrix cause fatal messages and decomposition is not attempted. If a system error occurs, a null column might result during decomposition in which case the column is labeled as a "Bad Column" and the decomposition is aborted.

5. A nonpositive definite matrix (decomposed diagonal element less than zero) causes the absolute value to be substituted only with the Cholesky option and if decomposition is to be continued.

6. The diagonal singularity test is,

$$e_s = \frac{2^{1-p}}{|D_{ii}/A_{ii}|} ,$$

where p is the number of bits in the mantissa (machine dependent), D_{ii} is the i^{th} diagonal term of the decomposed matrix, and A_{ii} is the i^{th} diagonal term of the input matrix, [A].

7. All matrix messages give the input and decomposed diagonal value except for situations where the input matrix is in error (e.g., the matrix is classified as rectangular or has a null column).

8. Nonconservative columns (identified by $D_{ii} > 1.001 * A_{ii}$) are identified.

9. Variable parameters output from functional modules must be SAVEd if they are to be subsequently used. See Executive Module SAVE instruction.

10. Setting MØDCØM(1) to -1 on the NASTRAN card (see Section 2.1) allows the time and core estimates to be made without actually doing the decomposition. Absolute values greater than 1 replace the variable CLØSE documented in Section 3.5.14.4 of the Programmer's Manual.

VIII. EXAMPLES:

1. To use the SDCMPS module in a static analysis (Rigid Format 1, Series Ø), modules SMP1 and RBMG2 must be removed. For this case, the required alters are as follows:

```
ALTER 78 $
PARAM    //C,N,PREC/V,N,MPREC $
ALTER 96, 97 $
VEC      USET/V/C,N,F/C,N,Ø/C,N,A $
CHKPNT   V $
PARTN    KFF,V,/KØØ,,KØA,KAAB $
CHKPNT   KØØ,KØA,KAAB $
SDCMPS   USET,GPL,SIL,KØØ/LØØ,/V,N,SYM/C,Y,DIAGCK=0/C,Y,DIAGET=20/
         C,Y,PDEFCK=0/V,N,SINGØ/C,N,Ø/C,N,0/V,N,DETØ/V,N,MINDIAØ/
         V,N,PØWERØ $
SAVE     SINGØ,DETØ,MINDIAØ,PØWERØ $
CØND     LSING,SINGØ $
CHKPNT   LØØ $
FBS      LØØ,,KØA/GØ/C,N,1/C,N,-1 $
CHKPNT   GØ $
MPYAD    KØA,GØ,KAAB/KAA/C,N,1/C,N,1/C,N,1/V,N,MPREC $
CHKPNT   KAA $
ALTER 105, 105 $
SDCMPS   USET,GPL,SIL,KLL/LLL,/V,N,SYM/C,Y,DIAGCK=0/C,Y,DIAGET=20/
         C,Y,PDEFCK=0/V,N,SINGL/C,N,L/C,N,0/V,N,DETL/V,N,MINDIAL/
         V,N,PØWERL $
SAVE     SINGL,DETL,MINDIAL,PØWERL $
CØND     LSING,SINGL $
ALTER 175 $
LABEL    LSING $
PRTPARM  //C,N,0/C,N,SINGØ $
PRTPARM  //C,N,0/C,N,SINGL $
PRTPARM  //C,N,-1/C,N,DMAP $
ENDALTER $
```

The input parameters SYM, DIAGCK, DIAGET, and PDEFCK may be changed from the values illustrated above by either using the form /C,N,i/ or by including a PARAM bulk data card with a different value.

2. To use the SDCMPS module in a real eigenvalue analysis (Rigid Format 3, Series Ø), modules SMP1 and RBMG2 must be removed. For this case, the required alters are as follows:

```
ALTER 81, 82 $
VEC      USET/V/C,N,F/C,N,Ø/C,N,A $
CHKPNT   V $
```

```
PARTN    KFF,V,/KØØ,,KØA,KAAB $
CHKPNT   KØØ,KØA,KAAB $
SDCMPS   USET,GPL,SIL,KØØ/LØØ,UØØ/V,N,SYM/C,Y,DIAGCK=0/C,Y,DIAGET=20/
         C,Y,PDEFCK=0/V,N,SINGØ/C,N,Ø/C,N,0/V,N,DETØ/V,N,MINDIAØ/
         V,N,PØWERØ $
SAVE     SINGØ,DETØ,MINDIAØ,PØWERØ $
CØND     LSING,SINGØ $
CHKPNT   LØØ,UØØ $
FBS      LØØ,UØØ,KØA/GØ/C,N,1/C,N,-1 $
CHKPNT   GØ $
MPYAD    KØA,GØ,KAAB/KAA/C,N,1 $
CHKPNT   KAA $
ALTER 89, 89 $
SDCMPS   USET,GPL,SIL,KLL/LLL,/V,N,SYM/C,Y,DIAGCK=0/C,Y,DIAGET=20/
         C,Y,PDEFCK=0/V,N,SINGL/C,N,L/C,N,0/V,N,DETL/V,N,MINDIAL/
         V,N,PØWERL $
SAVE     SINGL,DETL,MINDIAL,PØWERL $
CØND     LSING,SINGL $
ALTER 133 $
LABEL    LSING $
PRTPARM  //C,N,0/C,N,SINGØ $
PRTPARM  //C,N,0/C,N,SINGL $
PRTPARM  //C,N,-1/C,N,DMAP $
ENDALTER $
```

The input parameters SYM, DIAGCK, DIAGET, and PDEFCK may be changed from the values illustrated above as indicated under Example 1.

DIRECT MATRIX ABSTRACTION

I. NAME: SMPYAD (Matrix Series Multiply and Add)

II. PURPOSE: To multiply a series of matrices together and, optionally, add another matrix to the product:

$$[X] = [A][B][C][D][E] \pm [F] \ .$$

III. DMAP CALLING SEQUENCE:

```
SMPYAD   A,B,C,D,E,F / X / C,N,n / V,N,SIGNX / V,N,SIGNF / V,N,PX / V,N,TA /
         V,N,TB / V,N,TC / V,N,TD $
```

IV. INPUT DATA BLOCKS:

A, B, C, D, E - Up to 5 matrices to be multiplied together, from left to right.

F - Matrix to be added to the above product.

Notes:

1. If one of the five multiplication matrices is required in the product (see parameter n below) and is purged, the entire calculation is skipped.
2. If the [F] matrix is purged, no matrix will be added to the product.
3. The input matrices must be conformable. This condition is checked by SMPYAD.

V. OUTPUT DATA BLOCKS:

X - Resultant matrix (may not be pre-purged).

VI. PARAMETERS:

1. n = number of matrices involved in the product, counting from the left (integer, input)
2. SIGNX = sign of the product matrix (e.g., [A][B][C][D][E])
   = 1 for plus, -1 for minus (integer, input)
3. SIGNF = sign of the matrix to be added to the product matrix (integer, input)
   = 1 for plus, -1 for minus
4. PX = output precision of the final result (integer, input)
   = 1 for single-precision, 2 for double-precision, 0 logical choice based on input matrices.
5. TA, TB, TC, TD = transpose indicators for the [A],[B],[C], and [D] matrices (1 if transposed matrix to be used in the product; 0 if untransposed) - (integer, input)

Note:

All the parameters except n have default values as follows:

SIGNX = 1 (sign of product is plus)

SIGNF = 1 (sign of added matrix is plus)

PX = 0 (logical choice based on input matrices)

TA, TB, TC, TD = 0 (use untransposed [A],[B],[C], and [D] matrices in the product) (the number of transpose indicators required is one less than the number of matrices in the product. The last matrix in the product cannot be transposed.)

VII. METHOD:

The method is the same as for the MPYAD module with the following additional remarks:

1. None of the matrices may be diagonal.
2. Except for the final product, all intermediate matrix products are generated in double-precision.
3. The matrices are post-multiplied together from right-to-left, i.e., the first product calculated is the product of matrix n-1 and matrix n.

VIII. EXAMPLES:

1. To compute $[X] = [A][B]^T[C]-[F]$, use

```
SMPYAD   A,B,C,,,F / X / C,N,3 / C,N,1 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 $
```

2. To compute $[Z] = -[U]^T[V]^T[W]^T[X]^T[Y]$, use

```
SMPYAD   U,V,W,X,Y, / Z / C,N,5 / C,N,-1 / C,N,0 / C,N,0 / C,N,1 / C,N,1 /
         C,N,1 / C,N,1 $
```

DIRECT MATRIX ABSTRACTION

I. NAME: SØLVE (Linear System Solver)

II. PURPOSE: To solve the Matrix Equation

$$[A][X] = \pm [B]$$

III. DMAP CALLING SEQUENCE:

SØLVE A,B / X / V,Y,SYM / V,Y,SIGN / V,Y,PREC / V,Y,TYPE $

IV. INPUT DATA BLOCKS:

A - square real or complex matrix

B - rectangular real or complex matrix (if purged, the identity matrix is assumed).

V. OUTPUT DATA BLOCKS:

X - A rectangular matrix

Note: A standard matrix trailer will be written, identifying [X] as a rectangular matrix with the same dimensions as [B] and the type specified.

VI. PARAMETERS:

SYM - Input-integer, default = 0
- -1 - use unsymmetric decomposition
- 1 - use symmetric decomposition
- 0 - logical choice based on input matrices

- Output-integer: SYM used.

SIGN - Input-integer, default = 1
- 1 - solve [A][X] = [B]
- -1 - solve [A][X] = -[B]

PREC - Input-integer, default = 0
- 0 - logical choice based on input
- 1 - use single precision arithmetic
- 2 - use double precision arithmetic

- Output-integer: PREC used.

I. NAME: UMERGE (Merges two matrices based on USET)

II. PURPØSE: To merge two column matrices (such as load vectors or displacement vectors) into a single matrix.

III. DMAP CALLING SEQUENCE:

UMERGE USET,PHIA,PHIØ / PHIF / V,N,MAJØR=F / V,N,SUBO=A / V,N,SUB1=L $

IV. INPUT DATA BLØCKS:

USET - Uset [or U-set (Dynamics)]

PHIA, PHIØ - Any matrices

Note: 1. USET may not be purged.

2. PHIA or PHIØ may be purged in which case their respective elements will be zero.

3. PHIA, PHIØ and PHIF must be related by the following matrix equation

$$\left\{\frac{PHIA}{PHI\emptyset}\right\} \Longrightarrow \left\{PHIF\right\}$$

V. ØUTPUT DATA BLØCKS:

PHIF - matrix

Note: PHIF must not be purged.

VI. PARAMETERS:

MAJØR - BCD value from table on page 5.5-13 (Input, no default)

SUBO - BCD value from table on page 5.5-13 (Input, no default)

SUB1 - BCD value from table on page 5.5-13 (Input, no default)

Note: The set equation MAJØR = SUBO + SUB1 should hold.

DIRECT MATRIX ABSTRACTION

I. <u>NAME</u>: UPARTN (Partitions a matrix based on USET)

II. <u>PURPØSE</u>: To perform <u>symmetric</u> partitioning of displacement method matrices (particularly to allow user splitting of long running modules such as SMP1).

III. <u>DMAP CALLING SEQUENCE</u>:

UPARTN USET,KII / KJJ,KLJ,KJL,KLL / V,N,MAJØR=I / V,N,SUBO=J / V,N,SUB1=L $

IV. <u>INPUT DATA BLØCKS</u>:

USET - U-set [or U-set (Dynamics)]

KII - Any displacement matrix

<u>Note</u>: 1. USET may not be purged

2. KII may be purged in which case UPARTN will simply return, causing the output matrices to be purged.

V. <u>ØUTPUT DATA BLØCKS</u>:

$$\left.\begin{array}{l}\text{KJJ}\\ \text{KLJ}\\ \text{KJL}\\ \text{KLL}\end{array}\right\}\ \text{matrix partitions}$$

<u>Note</u>: 1. Any or all output data block(s) may be purged.

2. UPARTN forms:

$$\left[K_{ii}\right] \Longrightarrow \left[\begin{array}{c|c} K_{jj} & K_{j\ell} \\ \hline K_{\ell j} & K_{\ell\ell} \end{array}\right]$$

VI. <u>PARAMETERS</u>:

MAJØR - BCD value from table on page 5.5-13 (Input, no default)

SUBO - BCD value from table on page 5.5-13 (Input, no default)

SUB1 - BCD value from table on page 5.5-13 (Input, no default)

<u>Note</u>: The set equation MAJØR = SUBO + SUB1 should hold.

5.5 UTILITY MODULES

Utility modules are an arbitrary sub-division of the Functional Modules and are used to output matrix and table data blocks and to manipulate parameters.

The data block names corresponding to the various matrix and table data blocks used in the Rigid Format DMAP sequences may be found in Section 3 or in the NASTRAN mnemonic dictionary, Section 7.

I. NAME: CØPY

II. PURPOSE: To generate a physical copy of a data block.

III. DMAP CALLING SEQUENCE:

CØPY DB1 / DB2 / PARAM $

IV. INPUT DATA BLOCKS:

DB1 - Any NASTRAN data block

V. OUTPUT DATA BLOCKS:

DB2 - Any valid NASTRAN data block name

VI. PARAMETERS:

PARAM - If PARAM < 0 the copy will be performed - integer, input, default = -1.

VII. METHOD: If PARAM $\geq$ 0 a return is made, otherwise a physical copy of the input data block is generated.

VIII. REMARKS:

1. The input data block may not be purged.

VI. <u>PARAMETERS</u>: The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before reading.
0	Data blocks are read starting at the current position. The current position for the first use of a tape is at the label (P3). Hence, P3 counts as one Data Block.
-1	Rewind before reading, position tape past label (P3).
-3	Print data block names and then rewind before reading.
-5	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-6	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, fatal termination occurs.
-7	Search user tape for first version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.
-8	Search user tape for final version of data block (DBi) requested. If any (DBi) are not found, warning message is written on the output file and run continues.

The second parameter (P2) for this module is the FØRTRAN unit number from which the data blocks will be read. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine and installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 11).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used as the FØRTRAN User Tape Label for NASTRAN identification. The label (P3) is an alphanumeric variable of eight characters or less (the first character must be alphabetic). The value of P3 must match a corresponding value on the FØRTRAN User Tape. The comparison of P3 and the value or the User Tape is dependent on the value of P1 as shown in the table below. (The default valu for P3 is XXXXXXXX).

P1 Value	Tape Label Checked
+n	No
0	No
-1	Yes
-3	Yes (Warning Check)
-5	Yes
-6	Yes
-7	Yes
-8	Yes

VII. EXAMPLES:

INPUTT2 is intended to have the same logical action as the GINØ User Tape module INPUTT1 except for tape reel switching. It is therefore suggested that the examples shown under module INPUTT1 be used for INPUTT2 as well, excepting the ones involving tape reel switching.

I. NAME: LAMX (LAMA Data Block Editor or Generator)

II. PURPOSE: Allows modification of mode frequencies, which is useful in dynamics rigid formats. This can be used, for example, to test the effects of structural uncertainties. It does not require a new eigensolution.

III. DMAP CALLING SEQUENCE:

```
LAMX   EDIT,LAMA/LAMB/C,Y,NLAM $
```

IV. INPUT DATA BLOCKS:

EDIT - The editing instruction in the form of a DMI matrix.

LAMA - An output of the READ module which contains frequencies and generalized masses. If purged, the output is generated solely from EDIT information.

V. OUTPUT DATA BLOCKS:

LAMB - An edited version of LAMA, which is suitable for input to GKAM and ØFP modules, or a matrix from LAMA.

VI. PARAMETER:

NLAM - Integer. The maximum number of modes in the output data block. If NLAM = 0, the number of modes in LAMB is equal to that of LAMA. If NLAM < 0, LAMB will be a matrix.

VII. METHOD:

The DMI matrix (named EDIT in the above calling sequence) has one column for each mode. Each column has, at most, three entries (rows). Let R_{1n}, R_{2n}, and R_{3n} be the entries in the first through third rows of the nth column. The nth column will edit the frequency f_n and the generalized mass m_n of the nth mode. The rules defined below are such that a null column produces no change, while both a fixed frequency shift or a percentage change may be specified.

1. If $R_{3n} < 0$, delete the mode and decrease the mode number of higher modes.

2. If $R_{3n} \geq 0$,

$$\text{Frequency} = R_{1n} + (1+R_{2n})f_n$$

$$\text{Generalized mass} = \begin{cases} m_n , & R_{3n} = 0 \\ R_{3n} , & R_{3n} > 0 \end{cases}$$

The change for generalized mass is ignored unless data block MI is purged. The module will generate a LAMB data block if the second input is purged.

$$\text{Frequency} = R_{1n}$$
$$\text{Generalized mass} = R_{3n}$$

This second option is useful if modes are created external to NASTRAN and are input into the program via USER modules or DMI Bulk Data cards.

If NLAM is less than zero, a matrix will be built on LAMB. EDIT is ignored, and columns will be built with eigenvalue, omega, frequency, generalized mass, and generalized stiffness until the generalized mass is zero. The number of rows should then match the number of eigenvectors requested.

VIII. REMARKS:

1. LAMA may be purged. If LAMA is purged, than a LAMB is created from the EDIT information.

IX. EXAMPLES:

1. Assume that ten modes were found by READ and it is desired to do the following:

1 - 3	Leave alone
4	Multiply frequency by .8
5	Leave alone
6	Delete
7	Replace frequency by 173.20
8	Delete

The ALTER would be:

```
ALTER   XX
LAMX    LLLL,LAMA/LAMB/C,N,7 $
EQUIV   LAMB, LAMA/ALWAYS
```

This ALTER must be placed after READ and before GKAM. The DMI Bulk Data card would be:

1	2	3	4	5	6	7	8	9	10
DMI	LLLL	0	2	1	1		3	7	
DMI	LLLL	4	1	0.	-.2				
DMI	LLLL	6	1	0.	0.	-1.			
DMI	LLLL	7	1	173.20	-1.				

2. Create a LAMA with f_i = 10., 20., 30., 40., and m_i = 1., 1., 1., 2.

```
ALTER   XX
LAMX    EDIT,/LAMA $ DEFAULT PARAMETER IS ZERØ.
ØFP     LAMA,,,,,// $
```

1	2	3	4	5	6	7	8	9	10
DMI	EDIT	0	2	1	1		3	4	
DMI	EDIT	1	1	10.	0.	1.			
DMI	EDIT	2	1	20.	0.	1.			
DMI	EDIT	3	1	30.	0.	1.			
DMI	EDIT	4	1	40.	0.	2.			

Example 2:

(a) Objectives:

(1) Write data blocks A, B, and C on INPT.

(2) Obtain printout of the names of all data blocks on INPT after step (1).

(3) Make two copies of the tape created in (1).

(4) Add data blocks D and E to one of the tapes.

(5) Obtain the names of all data blocks on INPT after (4).

(b) DMAP Sequence:

```
BEGIN $                                  (1)
ØUTPUT1 A,B,C,, // C,N,-1 $              (2)
ØUTPUT1, ...., // C,N,-3 $               (3)
ØUTPUT1 A,B,C,, // C,N,-2 $              (4)
ØUTPUT1 A,B,C,, // C,N,-2 $              (5)
ØUTPUT1 D,E,,, // $                      (6)
ØUTPUT1, ...., // C,N,-3 $               (7)
END $                                    (8)
```

(c) Remarks:

(1) DMAP sequence (2) accomplishes objective (1) since the tape must initially have P3 written on it when first used. The DMAP statement INPUTT1 A,B,C,, // C,N,-1 $ will accomplish the same thing.

(2) DMAP sequence (3) accomplishes objective (2). The statement INPUTT1 / ...., / C,N,-3 $ will do the same thing and add a rewind.

(3) Statements (4) and (5) accomplish objective (3).

(4) Statement (6) accomplishes objective (4) where the third tape is used.

(5) Statement (7) accomplishes objective (5). The statement INPUTT1 / ...., / C,N,-3 $ will do the same thing and add a rewind.

(6) On machines where tape reel switching is not implemented, the second parameter can be used as follows:

```
BEGIN $
ØUTPUT1 A,B,C,, // C,N,-1 $
ØUTPUT1, ...., // C,N,-3 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,1 $
ØUTPUT1 A,B,C,, // C,N,-1 / C,N,2 $
ØUTPUT1 D,E,,, // C,N,0 / C,N,2 $
ØUTPUT1, ...., // C,N,-3 / C,N,2 $
END $
```

I. NAME: ØUTPUT2 (Create User Written FØRTRAN Tapes)
(The companion module is INPUTT2)

II. PURPØSE: Writes up to five data blocks and a user tape label onto a FØRTRAN-written user tape for subsequent use at a later date. ØUTPUT2 is also used to position the user tape prior to writing the data blocks. Multiple calls are allowed. A message is written on the output file for each data block successfully written. The user is cautioned to be careful when positioning a user tape with ØUTPUT2 since he may inadvertently destroy information through improper positioning. Even though no data blocks are written, an EØF will be written at the completion of each call which has the effect of destroying anything on the tape forward of the current position.

III. DMAP CALLING SEQUENCE:
ØUTPUT2 DB1,DB2,DB3,DB4,DB5 // V,N,P1 / V,N,P2 / V,N,P3 $

IV. INPUT DATA BLØCKS:
DBi - Any data block which the user desires to be written on one of the NASTRAN FØRTRAN tape files UT1, UT2, through UT5. Any or all of the input data blocks may be purged. Only nonpurged data blocks will be placed on the tape.

V. ØUTPUT DATA BLØCKS: None.

VI. PARAMETERS:
The meaning of the first parameter (P1) value is given in the table below. (The default value is 0).

P1 Value	Meaning
+n	Skip forward n data blocks before writing.
0	Data Blocks are written starting at the current position. The current position for the first use of a tape is at the label (P3). In this case P3 counts as one Data Block.
-1	Rewind before writing.
-3	Rewind tape, print data block names and then write after the last data block on the tape.
-9	Write a final EØF on the tape.

The second parameter (P2) for this module is the FØRTRAN unit number onto which the data blocks will be written. This unit is not required to be a physical tape. The allowable values for this parameter are highly machine or installation dependent. Reference should be made to Section 4 of the Programmer's Manual for a discussion of this problem. (The default value for P2 is 11).

User Tape Code	FØRTRAN File Name
11	UT1
12	UT2
13	UT3
14	UT4
15	UT5

The third parameter (P3) for this module is used to define the FØRTRAN User Tape Label. The label is used for NASTRAN identification. The label (P3) is an alphanumeric variable of eight or less characters (the first character must be alphabetic) which is written on the user tape. The writing of this label is dependent on the value of P1 as follows: (The default value for P3 is XXXXXXXX).

P1 Value	Table Label Written
+n	No
0	No
-1	Yes
-3	No (Warning Check)
-9	No

The user may specify the third parameter as V,Y,name. The user then must also include a PARAM card in the bulk data deck to set a value for name.

VII. EXAMPLES:

ØUTPUT2 is intended to have the same logical action as the GINØ User Tape module ØUTPUT1 except for tape reel switching. It is therefore suggested that the examples shown under module ØUTPUT1 be used for ØUTPUT2 as well, excepting the ones involving tape reel switching. All examples should be ended with a call to ØUTPUT2 with P1 = -9.

VIII. REMARKS:

The primary objective of this module is to write tapes using simple FØRTRAN so that a user can read NASTRAN generated data with his own program. Similarly, matrices can be generated with externally written simple FØRTRAN programs and then read by module INPUTT2.

In order to do this, the format of the information on these tapes must be adhered to. The basic idea is that a one word logical KEY record is written which indicates what follows. A zero value indicates an end-of-file condition. A negative value indicates the end of a record where the absolute value is the record number. A positive value indicates that the next record consists of that many words of data.

VII. METHØD: The nonzero elements of each matrix are punched on double-field DMI cards as shown in the example below. The name of the matrix is obtained from the header record of the data block. Field 10 contains the three character parameter value in columns 74-76 and an incremented integer card count in columns 77-80.

VIII. EXAMPLE:

Let the data block MAT contain the matrix

$$[MAT] = \begin{bmatrix} 1.0 & 0.0 & 6.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 0.0 & 7.0 & 0.0 & 0.0 & 0.0 \\ 2.0 & 4.0 & 0.0 & 0.0 & 0.0 & 0.0 \\ 0.0 & 5.0 & 0.0 & 0.0 & 0.0 & 9.0 \\ 3.0 & 0.0 & 8.0 & 0.0 & 0.0 & 0.0 \end{bmatrix}$$

The DMAP instruction OUTPUT3 MAT,,,, // C,N,0 / C,N,XYZ $ will then punch out the DMI cards shown below.

<table>
<tr><td>DMI</td><td>MAT</td><td>0</td><td>2</td><td>1</td><td>2</td><td></td><td>5</td><td>6</td><td>+XYZ 0</td></tr>
<tr><td>DMI*</td><td colspan="2">MAT</td><td colspan="2">1</td><td colspan="2">1</td><td colspan="2">1.000000E 00</td><td>*XYZ 1</td></tr>
<tr><td>*XYZ 1</td><td colspan="2">3</td><td colspan="2">2.000000E 00</td><td colspan="2">5</td><td colspan="2">3.000000E 00</td><td>*XYZ 2</td></tr>
<tr><td>DMI*</td><td colspan="2">MAT</td><td colspan="2">2</td><td colspan="2">3</td><td colspan="2">4.000000E 00</td><td>*XYZ 3</td></tr>
<tr><td>*XYZ 3</td><td colspan="2">5.000000E 00</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td>*XYZ 4</td></tr>
<tr><td>DMI*</td><td colspan="2">MAT</td><td colspan="2">3</td><td colspan="2">1</td><td colspan="2">6.000000E 00</td><td>*XYZ 5</td></tr>
<tr><td>*XYZ 5</td><td colspan="2">7.000000E 00</td><td colspan="2">5</td><td colspan="2">8.000000E 00</td><td colspan="2"></td><td>*XYZ 6</td></tr>
<tr><td>DMI*</td><td colspan="2">MAT</td><td colspan="2">6</td><td colspan="2">4</td><td colspan="2">9.000000E 00</td><td>*XYZ 7</td></tr>
</table>

IX. REMARKS:

1. Only real single- or double-precision matrices may be output.
2. All matrices are output on double-field cards in single-precision.
3. The maximum number of cards that may be punched is 9999. If matrices larger than this are desired, use module ØUTPUT2 and write a program to process the resulting FØRTRAN file.
4. The auxiliary subroutine PHDMIA used by module ØUTPUT3 can be used with stand-alone FØRTRAN programs. See Section 4 of the Programmer's Manual for details.

I. NAME: PARAM (Parameter Processor)

II. PURPOSE: To perform specified operations on integer DMAP parameters.

III. DMAP CALLING SEQUENCE:

```
PARAM // C,N,op / V,N,ØUT / V,N,IN1 / V,N,IN2 $
```

IV. INPUT DATA BLOCKS: None

V. OUTPUT DATA BLOCKS: None

VI. PARAMETERS:

1. op is a BCD operation code from the table below (Input, no default). Op is usually specified as a "C,N" parameter.
2. ØUT is the name of the parameter which is being generated by PARAM (output, integer, default = 1).
3. IN1 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).
4. IN2 is the name of a parameter whose value is used to compute ØUT according to the table below (Input, integer, default = 1).

VII. REMARKS:

1. The tables below give the results for ØUT as a function of op, IN1, and IN2.

Param	Arithmetic Operations				
op	ADD	SUB	MPY	DIV	NØT
ØUT	IN1+IN2	IN1-IN2	IN1·IN2	IN1/IN2	-IN1

Param	Logical Operations											
op	AND				ØR				IMPL			
IN1	<0	<0	≥0	≥0	<0	<0	≥0	≥0	<0	<0	≥0	≥0
IN2	<0	≥0	<0	≥0	<0	≥0	<0	≥0	<0	≥0	<0	≥0
ØUT	-1	+1	+1	+1	-1	-1	-1	+1	-1	+1	-1	-1

Param	Arithmetic Relational Operations																	
op	EQ			GE			GT			LE			LT			NE		
IN1-IN2	<0	=0	>0	<0	=0	>0	<0	=0	>0	<0	=0	>0	<0	=0	>0	<0	=0	>0
ØUT	+1	-1	+1	+1	-1	-1	+1	+1	-1	-1	-1	+1	-1	+1	+1	-1	+1	-1

Param	Special Operations
op	ØUT
NØP	ØUT (unchanged)
KLØCK	Current CPU time in integer seconds from the start of the job.
TMTØGØ	Remaining CPU time in integer seconds based on the TIME card.
PREC	Returns the currently requested precision; single precision (1) or double precision (2).
DIAG	Turn on DIAGs IN1 through IN2. IN1 ≥ IN2 will turn on DIAG IN1 IN1 < IN2 will turn on DIAG IN1 through DIAG IN2
DIAGØFF	Turn off DIAGs IN1 through IN2 as used for DIAG.
SSST	Turns DIAG |ØUT| on if ØUT ≤ 0. Turns DIAG ØUT off if ØUT > 0.
SSSR	Saves DIAG IN1 in ØUT if IN1 ≥ 0. Restores DIAG |IN1| to ØUT if IN1 < 0.
STSR	Saves SYSTEM(IN1) in ØUT if IN1 ≥ 0. Restores SYSTEM(IN1) to ØUT if IN1 < 0. (SYSTEM(IN1) is the IN1-th word in /SYSTEM/ common block.)
SYSR	Stores the value of IN1 from /SYSTEM/ into ØUT.
SYST	Sets the value from /SYSTEM/ where IN1 is the word and IN2 is the value of the parameter.

2. PARAM does its own SAVE: therefore a SAVE is not needed following the module.

VIII. EXAMPLES:

1. To change the sense of parameter NØXYZ (which may be useful for the CØND or EQUIV instructions):

   PARAM // C,N,NØT / V,N,XYZ / V,N,NØXYZ $ or
   PARAM // *NØT* / XYZ / NØXYZ $

   Alternatively, XYZ could have been set in the following way:

   PARAM // C,N,MPY / V,N,XYZ / V,N,NØXYZ / C,N,-1 $ or
   PARAM // *MPY* / XYZ / NØXYZ / -1 $

2. PARAM // C,N,IMPL / V,N,ABC / V,N,DEF / V,N,GHI $

3. To set the value of parameter P1 to 5 and save it for subsequent use:

   PARAM // C,N,NØP / V,N,P1=5 $ or
   PARAM // *NØP* / P1=5 $

4. To set parameter ABC to +1:

   PARAM // C,N,EQ / V,N,ABC / C,N,2 / C,N,-3 $ or
   PARAM // *EQ* / ABC / 2 / -3 $

5. To change the maximum number of lines of printed output:

   PARAM // C,N,SYST / V,N,DUM / C,N,14 / C,N,150000 $ or
   PARAM // *SYST* // 14 / 150000 $

   The 14th word in /SYSTEM/ common block is MXLINS whose default value is 20000, i.e., SYSTEM(14) = 20000. The equivalent operations to the PARAM examples shown above are to code SYSTEM(14) = 150000 or MXLINS = 150000 on the NASTRAN card or to use the Case Control card MAXLINES = 150000.

6. To turn on DIAGs 1 through 6:

   PARAM // C,N,DIAG / C,N, / C,N,1 / C,N,6 $ or
   PARAM // *DIAG* // 1 / 6 $

   This can also be done with the Executive Control card DIAG 1,2,3,4,5,6.

I. NAME: PARAML (Selects parameters from a list)

II. PURPOSE: To select parameters from a user input matrix or table.

III. DMAP CALLING SEQUENCE:

```
PARAML   INPUT // C,N,ØP / V,N,RECNØ / V,N,WØRDN /
         V,N,REAL1 / V,N,INTEG / V,N,REAL2 / V,N,BCD $
```

IV. INPUT DATA BLOCKS:

INPUT - Any matrix or table

V. OUTPUT DATA BLOCKS:

None.

VI. PARAMETERS:

ØP - Input-BCD-no default.

RECNØ - Input-integer-default = 1

WØRDN - Input-integer-default = 1

REAL1 - Output-real-default = 1.0

INTEG - Output-integer-default = 0

REAL2 - Output-real-default = 1.0

BCD - Output-BCD-default = blank

VII. REMARKS:

1. REAL1, INTEG, REAL2, and BCD will be set by the module whenever they are "V" type parameters.

2. RECNØ and WØRDN control the starting point, according to ØP.

   If ØP = DMI, RECNØ is the column number and WØRDN is the row number. If WØRDN > NRØW (the number of rows in the matrix), INTEG = NRØW and REAL1 = REAL2 = 0.0.

   If ØP = DTI, RECNØ is the record number and WØRDN is the word number.

   If ØP = NULL, INTEG = -1 if the sixth word of the matrix trailer, i.e., the matrix density, is zero.

   If ØP = PRESENCE, INTEG will be -1 if INPUT is purged.

   If ØP = TRAILER, WØRDN is output as the value of ith word of the matrix trailer where i is set by RECNØ in accordance with the following table.

RECNØ	TERM OF MATRIX TRAILER
1	Number of columns
2	Number of rows
3	Form of matrix
4	Type of matrix
5	Maximum number of nonzero terms in any column of the matrix
6	Matrix density

VIII. EXAMPLE:

Obtain the value in column 1, row 1 of a matrix.

```
PARAML    KGG//C,N,DMI/C,N,1/C,N,1/V,N,TERM $
```

I. NAME: PRTPARM (Parameter and DMAP Message Printer)

II. PURPØSE: A. Prints parameter values.

B. Prints DMAP messages.

III. DMAP CALLING SEQUENCE:

PRTPARM // C,N,a / C,N,b / C,N,c $

IV. INPUT DATA BLØCKS: None

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

a - Integer value (no default value)

b - BCD value (default value = XXXXXXXX)

c - Integer value (default value = 0)

VII. METHØD:

A. As a parameter printer, use a = 0. There are two options:

1. b = parameter name will cause the printout of the value of that parameter.

   Example: PRTPARM // C,N,0 / C,N,LUSET $

2. b = XXXXXXXX will cause the printout of the values of all parameters in the current variable parameter table. Since this is the default value, it need not be specified.

   Example: PRTPARM // C,N,0 $

B. As a DMAP message printer, use a ≠ 0. There are two options:

1. a > 0 causes the printout of the j^{th} message of category b where $j=|a|$ and b is one of the values shown below. (The number of messages available in each category is also given.)

   Example: PRTPARM // C,N,1 / C,N,DMAP $

2. a < 0 causes the same action as a > 0 with the additional action of program termination. Thus, PRTPARM may be used as a fatal message printer.

   Example: PRTPARM // C,N,-2 / C,N,PLA $

VIII. REMARKS:

1. b is always a value.

2. Meaningless values of a and b will result in diagnostic messages from PRTPARM.

3. TABLE OF b CATEGORY VALUES

	DISPLACEMENT Rigid Formats	Value of b	Number of Messages
1	Static Analysis	STATICS	5
2	Static Analysis with Inertia Relief	INERTIA	5
3	Normal Mode Analysis	MODES	3
4	Static Analysis with Differential Stiffness	DIFFSTIF	4
5	Buckling Analysis	BUCKLING	6
6	Piecewise Linear Analysis	PLA	5
7	Direct Complex Eigenvalue Analysis	DIRCEAD	3
8	Direct Frequency and Random Response	DIRFRRD	4
9	Direct Transient Response	DIRTRD	3
10	Modal Complex Eigenvalue Analysis	MDLCEAD	4
11	Modal Frequency and Random Response	MDLFRRD	6
12	Modal Transient Response	MDLTRD	5
13	Normal Modes Analysis with Differential Stiffness	NMDSTIF	6
14	Static Analysis with Cyclic Symmetry	CYCSTAT	6
15	Normal Modes Analysis with Cyclic Symmetry	CYCMØDES	6
	HEAT Rigid Formats		
1	Static Heat Transfer	HSTAT	4
3	Nonlinear Static Heat Transfer	HNLIN	3
9	Transient Heat Transfer	HTRD	1
	AERØ Rigid Formats		
10	Modal Flutter Analysis	FLUTTER	4
11	Modal Aeroelastic Response	AERØRESP	3
	Direct Matrix Abstraction Program		
	DMAP	DMAP	See Remark 5

4. For details on error messages for the i^{th} Displacement Rigid Format see section 3.(i + 1). User's Manual. The Heat and Aero Rigid Formats follow these.

5. The message number, a, may be any integer for DMAP messages.

6. The third parameter is not currently used.

I. NAME: SCALAR (Convert matrix element to parameter)

II. PURPOSE: To extract a specified element from a matrix for use as a parameter.

III. DMAP CALLING SEQUENCE:

SCALAR A//V,Y,NRØW=1/V,N,NCØL=1/C,Y,VALUE $

IV. INPUT DATA BLOCKS:

A - may be any type of matrix.

NOTE: If A is purged, value will be returned as (0.,0.).

V. OUTPUT DATA BLOCKS:

None

VI. PARAMETERS:

NRØW - Input-integer, default=1. Row number of element to be extracted from [A].

NCØL - Input-integer, default=1. Column identification of element.

VALUE - Output-complex-single precision, default=(0.,0.). Contents of element (NRØW,NCØL) in matrix [A].

I. NAME: SEEMAT (Pictorial Matrix Printer)

II. PURPØSE: Shows nonzero matrix elements on printer or plotter output positioned pictorially by row and column within the outlines of the matrix.

III. DMAP CALLING SEQUENCE:

SEEMAT M1,M2,M3,M4,M5 // C,N,$\begin{Bmatrix}\text{PRINT}\\\text{PLØT}\end{Bmatrix}$ / V,N,PFILE / V,N,PACK / C,N,plotter /
C,N,modeln1 / C,N,modelb1 / C,N,modeln2 / C,N,modelb2 /
C,N,sizex / C,N,sizey $

IV. INPUT DATA BLØCKS:

Matrix Data Blocks, any of which may be purged.

V. ØUTPUT DATA BLØCKS: None

VI. PARAMETERS:

1. PRINT implies use of the system output file. (Any value other than PLØT implies PRINT.)

   PLØT implies use of one of the plotters (see Section 4.1).

   The default value for the first parameter is PRINT.

2. PFILE is the Plot File Number. (Used only if first parameter is PLØT.)

   Input/output variable integer parameter. Frame or sheet number. The value of this parameter will be incremented by one (1) for each frame (sheet) plotted by SEEMAT.

   The default value for the second parameter is 0.

3. PACK is reserved for a future modification that will allow the representation of a nonzero block of the matrix with a single character.

   The default value for the third parameter is 100.

4. Plotter Name - If the first parameter = PLØT, one of the plotter names must be selected from the following list. Additional information on plotters and the meaning of the symbols used below is given in Section 4. The associated model identifiers are specified with the next four parameters. Each plotter has a default model associated with it, as indicated by the underlined model identifier.

   The default value for the fourth parameter is SC.

Plotter Name	Model Identifiers
<u>SC</u>	<u>4020,0</u>
CALCØMP	$\left\{\begin{matrix}\underline{7651}\\7631\\7655\\7635\end{matrix}\right\}, \left\{\begin{matrix}781\\780\\773\\772\\771\\\underline{770}\end{matrix}\right\}$ $\left\{\begin{matrix}5651\\5631\\5655\\5635\end{matrix}\right\}, \left\{\begin{matrix}763\\762\\761\\760\\751\\750\end{matrix}\right\}$
NASTPLT	$\left\{\begin{matrix}\underline{M,0}\\T,0\\D,0\\M,1\\T,1\\D,1\end{matrix}\right\}$

5. The parameter modeln1 is used to specify the first of the two model identifiers when it is an integer value. The default value for the fifth parameter is 0.
6. The parameter modelb1 is used to specify the first of the two model identifiers when it is a BCD value. The default value for the sixth parameter is blank.
7. The parameter modeln2 is used to specify the second of the two model identifiers when it is an integer value. The default value for the seventh parameter is 0.
8. The parameter modelb2 is used to specify the second of the two model identifiers when it is a BCD value. The default value for the eighth parameter is blank.

9. The parameter sizex specifies the size of the plotter surface x-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizex is 30.0.

10. The parameter sizey specifies the size of the plotter surface y-dimension on those plotters for which it is appropriate (e.g., the CALCØMP plotter). The default value for sizey is 30.0.

VII. METHØD: The matrix is partitioned into blocks which can be printed on a single sheet of output paper or frame on the plotter selected. Only blocks containing nonzero elements will be output. Row and column indices are indicated. The user of this module is cautioned to make sure his line count limit is large enough. A default of 20,000 lines is provided by NASTRAN. This may be changed via the statement MAXLINES= value in the NASTRAN Case Control Deck. The transpose of the matrix is output.

VIII. REMARKS:

1. If a plotter is used, the file PLT2 (either tape or mass storage area) must be made available to NASTRAN.
2. If a plotter is used, a SAVE instruction should be executed to update PFILE.
3. The nonzero elements are indicated by asterisks (*), except for diagonal elements of square matrices which are indicated by the letter D, and elements in the last row or column which are indicated by dollar signs ($).
4. The default model for any plotter is specified by omitting the last four parameters.
5. When two of the last four parameters are used to specify model identifiers, the remaining two parameters should be specified as C,N only.

IX. EXAMPLES:

1. Specify CALCØMP 7651,770 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,CALCØMP $
```

2. Specify SC 4020 as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE $
```

3. Specify the general purpose plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // C,N,PLØT / V,N,PFILE / C,N / C,N,NASTPLT / C,N /
                          C,N,D / C,N,1 / C,N $
```

4. Specify the printer rather than a plotter as follows:

```
SEEMAT  M1,M2,M3,M4,M5 // $
```

5. For additional examples see Section 5.8.8.

I. NAME: TABPCH (Table Punch)

II. PURPOSE: To punch NASTRAN tables onto DTI cards in order to allow transfer of data from one NASTRAN run to another, or to allow user postprocessing.

III. DMAP CALLING SEQUENCE:

TABPCH TAB1,TAB2,TAB3,TAB4,TAB5 // C,N,A1 / C,N,A2 / C,N,A3 / C,N,A4 / C,N,A5 $

IV. INPUT DATA BLOCKS:

TAB1	
TAB2	
TAB3	Any NASTRAN Tables
TAB4	
TAB5	

V. OUTPUT DATA BLOCKS:

None - All output is punched onto DTI cards.

VI. PARAMETERS:

A1, A2, A3, A4, A5 -- Input - BCD - Defaults are 'AA', 'AB', 'AC', 'AD', 'AE'. These parameters are used to form the first two characters (columns 74, 75) of the continuation field for each table respectively.

VII. REMARKS:

1. Any or all tables may be purged.
2. Integer and BCD characters will be punched onto single-field cards. Real numbers will be punched onto double-field cards. Their formats are I8, 2A4, E16.9.
3. Up to 99,999 cards may be punched per table.
4. Currently, twice the entire record must fit in open core.
5. Tables with 1 word BCD values (ELSETS) cannot be punched correctly.

VIII. EXAMPLES:

TABPCH EST,,,, // C,N,ES $ will punch the EST onto cards with a continuation neumonic of $+ES_{bbbb}i$ (where i is the sequence number).

I. NAME: VEC (Creates partitioning vector based on USET).

II. PURPØSE: To create a partitioning vector for displacement method matrices using USET that may be used by Matrix Operation Modules MERGE and PARTN. This allows the user to split up long running modules such as SMP1.

III. DMAP CALLING SEQUENCE:

A. For matrices generated in Rigid Formats 1-6 or prior to module GKAD (or GKAM) in Rigid Formats 7-12:

```
VEC  USET / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

B. For matrices generated in Rigid Formats 7-12 after module GKAD (or GKAM):

```
VEC  USETD / V / C,N,SET / C,N,SET0 / C,N,SET1 / V,N,ID $
```

IV. INPUT DATA BLØCKS:

USET - U-set

or

USETD - U-set (Dynamics)

Note: U-set may not be missing and must fit into open core.

V. ØUTPUT DATA BLØCKS:

V - Partitioning vector.

Note: 1. If all elements are in SET0 or SET1 then V will be purged.

2. V may not be purged prior to execution.

VI. PARAMETERS:

SET - Matrix set to be partitioned (Input ,BCD, no default.)

SET0 - Upper partition of SET (Input ,BCD, no default).

SET1 - Lower partition of SET (Input ,BCD, no default).

ID - Identification of bit position (see Remarks) (Input, integer, default = 0).

Note: 1. Legal parameter values are given in the table on page 5.5-13.

2. See Section 1.7.3 of the Programmer's Manual for a description of set notation or Section 3.3 of the Theoretical Manual.

VII. REMARKS:

1. Parameters SET0 and SET1 must be a subset of the SET matrix parameter. A degree of freedom may not be in both subsets.

2. If desired, one of SET0 or SET1 but not both may be requested to be the complement of the other one by giving it a value of CØMP.

3. If SET = BITID, the second and third parameters are ignored and the IDth bit position in USET (or USETD) is used. In this case, SET is assumed equal to G (or P) and SET0 will correspond to the zero's in the IDth position and SET1 will correspond to the non-zero's in the IDth position.

VIII. EXAMPLES:

1. To partition $[K_{ff}]$ into a- and o- set based matrices, use

    VEC   USET / V / C,N,F / C,N,Ø / C,N,A $

    PARTN KFF,V, / KØØ,KAØ,KØA,KAA $

    Note that the same thing can be done in one step by

    UPARTN USET,KFF / KØØ,KAØ,KØA,KAA / C,N,F / C,N,Ø / C,N.A $

2. Example 1 could be accomplished by

    VEC   USET / V / C,N,F / C,N,Ø / C,N,CØMP $

    or

    VEC   USET / V / C,N,F / C,N,CØMP / C,N,A $

3. Example 1 could be accomplished by

    VEC   USET / V / C,N,BITID / C,N,X / C,N,X / C,N,25 $

EXAMPLES

```
BEGIN     $
GP1       GEØM1,GEØM2, / GPL,EQEXIN,GPDT,CSTM,BGPDT,SIL / V,N,LUSET / C,N,0 / C,N,0 $
SAVE      LUSET $
GP4       CASECC,,EQEXIN,SIL,GPDT,BGPDT,CSTM / ,,USET, / V,N,LUSET / C,N,0 / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 $
DPD       DYNAMICS,GPL,SIL,USET / GPLD,SILD,USETD,,,,,,,EED,EQDYN / V,N,LUSET / C,N,0 /
          C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / C,N,0 / V,N,NØEED / C,N,0 / C,N,0 $
SAVE      NØEED $
CØND      E1,NØEED $
READ      KTEST,MTEST,,,EED,,CASECC / LAMA,PHIA,MI,ØEIGS / C,N,MØDES / V,N,NEIGV $
SAVE      NEIGV $
ØFP       LAMA,ØEIGS,,,, // $
CØND      FINIS,NEIGV $
SDR1      USET,,PHIA,,,,,,,, / PHIG,, / C,N,1 / C,N,REIG $
SDR2      CASECC,,,,EQEXIN,SIL,,,BGPDT,LAMA,,PHIG,,, / ,,ØPHIG,,, / C,N,REIG $
ØFP       ØPHIG,,,,, // $
JUMP      FINIS $
LABEL     E1 $
PRTPARM   // C,N,-2 / C,N,MØDES $
LABEL     FINIS $
END       $
```

Notes:

1. The echo of a test problem bulk data deck for the preceding DMAP sequence follows.

. 1 ..	2 ..	3 ..	4 ..	5 ..	6 ..	7 ..	8 ..	9 ..	10 .
DMI	KTEST	0	6	1	2		4	4	
DMI	KTEST	1	1	200.0	-100.0				
DMI	KTEST	2	1	-100.0	200.0	-100.0			
DMI	KTEST	3	2	-100.0	200.0	-100.0			
DMI	KTEST	4	3	-100.0	200.0				
DMI	MTEST	0	6	1	2		4	4	
DMI	MTEST	1	1	1.0					
DMI	MTEST	2	2	1.0					
DMI	MTEST	3	3	1.0					
DMI	MTEST	4	4	1.0					
EIGR	1	DET	.0	2.5	2	2			+1
+1	MAX								
SPØINT	1	THRU	4						

2. Data block EED is generated by DPD, which copies the EIGR or EIGB cards from data block DYNAMICS. The actual card used is selected in case control by METHOD = SID.

3. Each degree-of-freedom defined by the DMI matrices must be associated with some grid or scalar point in this version. In the example above, this is done by defining four scalar points.

4. The EIGR card selected in the Case Control Deck will be used as explained in Note 2.

5. The use of module MTRXIN and DMIG bulk data cards will allow the user to input matrices via grid point identification numbers.

5.8.8 DMAP Example to Print and Plot a Topological Picture of Two Matrices

```
 1.  BEGIN    $
 2.  SEEMAT   KGG,KLL,,, // $
 3.  SEEMAT   KGG,KLL,,, // C,N,PLØT / V,N,P=0 / C,N / C,N,SC / C,N,4020 / C,N,X / C,N,0 $
 4.  SAVE     P $
 5.  PRTPARM  // C,N,0 / C,N,P $
 6.  PARAM    // C,N,MPY / V,N,P / C,N,0 / C,N,1 $
 7.  SEEMAT   KGG,KLL,,, // C,N,PLØT / V,N,P / C,N / C,N,NASTPLT / C,N,D / C,N,X / C,N,D $
 8.  SAVE     P $
 9.  PRTPARM  // C,N,0 / C,N,P $
10.  END      $
```

Notes:

1. Instruction number 2 causes the picture to be generated on the printer.

2. Instruction number 3 causes the picture to be generated on the SC 4020 plotter.

3. The parameter P is initialized to zero by instruction number 3. The form V,N,P would also have accomplished the same thing since the MPL default value is zero.

4. Instruction number 5 prints the current value of parameter P. Since P was initially set to zero and instruction number 3 is the first instruction executed which has P as an input, then P will have a zero value on input to instruction number 3. P is incremented by one (1) for every frame generated on the SC 4020 plotter. Since the value of the output parameter P was saved in the immediately following SAVE instruction, the value printed by instruction number 5 will be the number of frames generated by the execution of instruction number 3.

5. Instruction number 6 causes the value of P to be set to zero (0), the product of zero (0) and one (1). Since PARAM is the only module which does its own SAVE, no succeeding SAVE instruction is necessary. This illustrates a commonly used technique for setting parameter values in DMAP programs.

6. Instructions 7, 8 and 9 essentially repeat instructions 3, 4 and 5 using the general purpose plotter in place of the SC 4020 plotter.

7. The END instruction, which is required, also acts as an EXIT instruction.

8. NASTRAN file PLT2 must be set up in order to execute this DMAP successfully.

9. Matrix data blocks KGG and KLL are assumed to exist on the PØØL file. This will be the case if either DMI input is used or if a restart is being made from a run in which KGG and KLL were generated and checkpointed.

5.9.10 DMAP for Command: SØLVE

The SØLVE command provides the necessary data for execution of the solution phase of NASTRAN. Module SGEN replaces the NASTRAN GP1 module for the purpose of defining an equivalent pseudostructure from data blocks. The new data blocks GE3S and GE4S contain the load and constraint data in the form of converted Bulk Data card images. The stiffness and mass matrices are obtained from the SØF files and added to any user matrix terms.

Raw DMAP:

```
ALTER     (Remove GP1)
PARAM     //C,N,NØP/V,N,ALWAYS=-1 $
SGEN      CASECC,GEØM3,GEØM4/CASESS,CASEI,GPL,EQEXIN,GPDT,BGPDT,SIL,
          GE3S,GE4S,CSTM/V,N,DRY/C,N,NAMESØLS/V,N,LUSET/V,N,NØGPDT $
SAVE      DRY,LUSET,NØGPDT $
EQUIV     GE3S,GEØM3/ALWAYS/GE4S,GEØM4/ALWAYS/CASEI,CASECC/ALWAYS $
CØND      LBSTP/DRY $
ALTER     (Remove PLØT)
ALTER     (Remove NØSIMP CØND)
CØND      LBSØL,NØSINP $
ALTER     (Remove SMA3)
LABEL     LBSØL $
SØFI      /KNØS,MNØS,,,/V,N,DRY/C,N,NAMESØLS/C,N,KNTX/C,N,MMTX $
EQUIV     KNØS,KGG/NØSIMP $  (K only)
EQUIV     MNØS,MGG/NØSIMP $  (M, only used for Rigid Formats 2 and 3)
CØND      LBSTP,NØSIMP $
ADD       KGGX,KNØS/KGG/ $   (K only)
ADD       MGG,MNØS/MGGX/ $
EQUIV     MGGX,MGG/ALWAYS $      (M, only used for Rigid Formats 2 and 3)
LABEL     LBSTP
CHKPNT    MGG $  (M, only used for Rigid Formats 2 and 3)
ALTER     (After GP4)
CØND      LBSEND,DRY $
ALTER     (Remove SDR2-PLØT)
```

Variables

NAMESØLS	= Name of solution structure
NØS	= Internal number of solution structure
STP	= Step number

5.9.11 DMAP for Command: SUBSTRUCTURE

The SUBSTRUCTURE command is necessary to initiate the automatic DMAP process. In Phase 1, the SUBPH1 module is used to build the substructure tables on the SØF from the NASTRAN grid point tables and the SØFØ module is used to copy the matrices onto the SØF. In Phase 2 and Phase 3, the initial value of the DRY parameter is set and the DMAP sequence is initiated.

Raw DMAP:

PHASE 1

```
ALTER      (After GP4)
PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL      LBSBEG $
CØND       LBLIS,DRY $
ALTER      (Remove DECØMP)
LABEL      LBLIS $
ALTER      (Remove solution)
SUBPH1     CASECC,EQEXIN,USET,BGPDT,CSTM,GPSETS,ELSETS//V,N,
           DRY/C,N,NAME/C,N,PLØTID/C,N,PØPT $
SAVE       DRY $
CØND       LBSEND,DRY $
EQUIV      PG,PL/NØSET $
CØND       LBL10,NØSET $
SSG2       USET,GM,YS,KFS,GØ,,PG/QR,PØ,PS,PL $ (P or PA only)
CHKPNT     PØ,PS,PL $
LABEL      LBL10 $
SØFØ       ,KAA,MAA,PL,,//V,N,DRY/C,N,NAME/C,N,KMTX/C,N,MMTX/C,N,PVEC $
LØDAPP     PL,//V,N,DRY/C,N,NAME $ (PA only)
```

PHASE 2

```
ALTER      2,0
PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL      LBSBEG $
```

PHASE 3

```
ALTER      (Remove DECØMP)
PARAM      //C,N,ADD/V,N,DRY/C,N,I/C,N,0 $
LABEL      LBSBEG $
```

Variables:

I	=	Integer RUN option code (see RUN command)
NAME	=	Phase 1 substructure name
PLØTID	=	Phase 1 Plot Set ID
KAA,MAA,PL	=	Data blocks dependent on ØPTIØN
PØPT	=	Flag for appended loads (ØPTIØN=PA)

5.10 SUPPLEMENTARY FUNCTIONAL MODULES

These modules are fully described in Section 4 of the Programmer's Manual. However since they are not incorporated in any of the Rigid Formats, they are included here for reference purposes. These modules must be altered into the Rigid Format when it is desired to include a request for forces of multipoint constraint in the Case Control Deck (see Section 2.3 for a description of the MPCFØRCE card) or to automatically constrain possible stiffness matrix singularities.

I. NAME: EQMCK (Calculate Forces of Multipoint Constraint)

II. PURPOSE: EQMCK calculates an overall total of forces and moments on the entire structure to provide an equilibrium check and creates the multipoint constraint force output file.

III. DMAP CALLING SEQUENCE:

EQMCK CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,$\left\{\begin{matrix}\text{PHIG}\\ \text{UGV}\end{matrix}\right\}$,$\left\{\begin{matrix}\text{LAMA}\\ \text{PGG}\end{matrix}\right\}$,QG,CSTM / ØQM1 / V,Y,ØPT / V,Y,GRDEQ / V,N,NSKIP / V,Y,SUBNAM $

IV. INPUT DATA BLOCKS:

CASECC - Case control data table

EQEXIN - Equivalent external-internal grid point table

GPL - Grid point list table

BGPDT - Basic grid point definition table

SIL - Scalar index list table

USET - Displacement set definition table

KGG - Stiffness matrix - g set

GM - Multipoint constraint transformation matrix - m set

PHIG - Real eigenvector - g set

UGV - Displacement vector matrix - g set

LAMA - Real eigenvalue table

PGG - Static load vector - g set

QG - Single-point constraint force and determinate support force matrix - g set

CSTM - Coordinate system transformation matrix

Note: GM, PGG, QG, and CSTM may be purged.

V. OUTPUT DATA BLOCKS

ØQM1 - Output multipoint constraint force (m set, SØRT1, real)

Note: ØQM1 may be purged if GM is purged. See also parameter ØPT.

VI. PARAMETERS:

ØPT - Input, integer, default = 0. ØPT controls printed output.

0 - only create ØQM1

< 0 - calculate equilibrium forces

> 0 - equilibrium forces and ØQM1 created

GRDEQ - Input, integer, default = -1. GRDEQ selects the grid point about which equilibrium will be checked. The basic origin is used if GRDEQ is not an external ID of a geometric grid point.

NSKIP - Input, integer, no default. If NSKIP > 1, this is a statics problem with NSKIP corresponding to the first CASECC record to use. If NSKIP $\leq$ 0, this is a real eigenvalue problem, without DMAP loop capability.

SUBNAM - Input, BCD, default = NØNE. Reserved for future use.

VII. METHOD: All user errors are considered nonfatal. An example is when ØPT = 0 and no MPCs exist in the problem - no execution is required and the module exists. If needed data blocks are required but missing for the selected output, the module exits. A message informs the user of the exit condition.

Overall equilibrium of loads and reactions is calculated from:

1. Directly applied statics loads $\{P_g\}$

2. Forces of single-point constraint and determinant support reactions $\{q_g\}$

3. Forces of multi-point constraint $\{q_m\}$

VIII. REMARKS:

1. For static analysis (NSKIP > 0), the format of the equilibrium force output (ØPT $\neq$ 0) for the Case Control request MPCFØRCE = n, is as follows:

RESULTANT LØADS AT PØINT XXX IN BASIC CØØRDINATE SYSTEM

SUBCASE XX, LØAD XX

-TYPE-	T1	T2	T3	R1	R2	R3
APPLIED	X.XX	X.XX	X.XX	X.XX	X.XX	X.XX
SPCFØRCE						
MPCFØRCE						
---TØTAL						

SUBCASE XX, LØAD XX

-(repeated for all subcases in the current DMAP loop)-

In addition, a separate output listing for the forces of multipoint constraint is produced in SØRT1 format as, for example, forces of single point constraint. When ØPT = 0 only the forces of multipoint point constraint are listed in the output in SØRT1 format.

2. For real eigenvalue analysis (NSKIP $\leq$ 0), the format of the subheading is as follows:

   SUBCASE XX, MØDE XX, FREQUENCY X.XX

   The tabulated listing of the equilibrium forces (ØPT $\neq$ 0) is the same as above for the Case Control request MPCFØRCE = n. In addition, a separate output listing for the forces of multipoint constraint is produced in SØRT1 format as, for example, forces of single point constraint. When ØPT = 0, only the forces of multipoint point constraint are listed in the output in SØRT1 format.

IX. EXAMPLES:

1. To obtain the forces of multipoint constraint (MPCFØRCE request in the Case Control Deck) in a static analysis (Rigid Format 1, Series Ø), an alter in the Executive Control Deck must be made:

```
ALTER 136 $
EQMCK   CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,UGV,PGG,QG,CSTM/
        ØQM1/V,Y,ØPT=0/V,Y,GRDEQ=0/V,N,NSKIP/V,N,SUBNAM $
ØFP     ØQM1,,,,,//V,N,CARDNØ $
SAVE    CARDNØ $
ENDALTER $
```

   Input parameters, ØPT and GRDEQ, can be changed from the initial value illustrated for the general case, by either using the form C,N,i or by using a PARAM bulk data card with a different value.

2. To obtain the forces of multipoint constraint (MPCFØRCE request in the Case Control Deck) in a real eigenvalue analysis (Rigid Format 3, Series Ø), an alter in the Executive Control Deck must be made:

```
ALTER 109 $
EQMCK   CASECC,EQEXIN,GPL,BGPDT,SIL,USET,KGG,GM,PHIG,LAMA,QG,CSTM/
        ØQM1/V,Y,ØPT=0/V,Y,GRDEQ=0/V,N,NSKIP/V,N,SUBNAM $
ØFP     ØQM1,,,,,//V,N,CARDNØ $
SAVE    CARDNØ $
ENDALTER $
```

   Input parameters, ØPT and GRDEQ, can be changed from the initial value illustrated for the general case, by either using the form C,N,i or by using a PARAM bulk data card with a different value.

C-9

I. NAME: GPSPC (Cosntrain Stiffness Matrix Singularities)

II. PURPOSE: The GPST data block contains data on possible stiffness matrix singularities. These singularities may have been removed through the application of single or multipoint constraints. The GPSPC module checks each singularity against the list of constraints, and if the singularity is not thereby removed, writes a warning for the user and on user's option automatically constrains the singularity. This module will not be used if GENELs are present.

III. DMAP CALLING SEQUENCE:

```
GPSPC   GPL,GPST,USET,SIL / ØGPST,USETC / V,N,NØGPST / V,Y,SINCØN / V,N,SINGLE /
        V,N,ØMIT / V,N,REACT / V,N,NØSET / V,N,NØL / V,N,NØA $
```

IV. INPUT DATA BLOCKS:

GPL - Grid Point List

GPST - Grid Point Singularity Table

USET - Displacement Set Definitions Table

SIL - Scalar Index List

Note: No input data block can be purged.

V. OUTPUT DATA BLOCKS:

ØGPST - Tabular list of grid point singularities not removed by user. This data block will be processed by the ØFP (Output File Processor) module.

USETC - Displacement Set Definition Table with singularities constrained.

VI. PARAMETERS:

NØGPST - Output, integer, default = 1. If positive, ØGPST was created.

SINCØN - Input-output, integer, default = -1. If SINCØN is negative on input, remaining singularities are automatically constrained. On output, same negative value if singularities existed, zero otherwise.

SINGLE, ØMIT, REACT, NØSET, NØL, NØA - Input-output, integer, no default. See description of GP4 parameters of the same name in Programmer's Manual Section 4.31. Values are corrected only if singularities were constrained.

VII. NASTRAN CARD PARAMETER:

See Section 2.1 for NASTRAN card parameter, STST, used with this module.

VIII. EXAMPLES:

1. To use the GPSPC module instead of the standard GPSP module in a static analysis (Rigid Format 1, Series Ø), module GPSP is replaced by module GPSPC and USET is replaced by USETC. In this case, the following alters are required:

```
ALTER 70, 72 $
CHKPNT    RG,YS,USET,ASET $
ALTER 74, 75 $
GPSPC     GPL,GPST,USET,SIL/ØGPST,USETC/V,N,NØGPST/V,Y,SINCØN=-1/
          V,N,SINGLE/V,N,ØMIT/V,N,REACT/V,N,NØSET/V,N,NØL/V,N,NØA $
SAVE      NØGPST,SINCØN,SINGLE,ØMIT,REACT,NØSET,NØL,NØA $
EQUIV     USETC,USET/SINCØN $
CHKPNT    USET $
ALTER 77 $
PARAM     //C,N,ADD/V,N,SING/V,Y,SINCØN/C,N,1 $
CØND      ERRØR3,NØL $
CØND      ERRØR,SING $
ALTER 78 $
PARAM     //C,N,AND/V,N,NØSR/V,N,SINGLE/V,N,REACT $
PURGE     KRR,KLR,QR,DM/REACT /GM/MPCF1 /GØ,KØØ,LØØ,PØ,UØØV,RUØV/ØMIT /
          PS,KFS,KSS/SINGLE /QG/NØSR $
CHKPNT    KRR,KLR,QR,DM,GM,GØ,KØØ,LØØ,PØ,UØØV,RUØV,PS,KFS,KSS,QG $
LABEL     ERRØR $
PRTPARM   //C,N,O/C,N,SINCØN $
ENDALTER $
```

Input parameter SINCØN can be changed from the initial value illustrated for the general case, by either using the form C,N,i or by using a PARAM bulk data card with a different value. Note that when SINCØN = -1, the strongest combination of possible singularities is automatically constrained and noted in the GPST output.

2. To use the GPSPC module instead of the standard GPSP module in a real eigenvalue analysis (Rigid Format 3, Series Ø), module GPSP is replaced by module GPSPC and USET is replaced by USETC. In this case, the following alters are required:

```
ALTER 55, 56 $
CHKPNT    RG,USET,ASET $
ALTER 58, 59 $
GPSPC     GPL,GPST,USET,SIL/ØGPST,USETC/V,N,NØGPST/V,Y,SINCØN=-1/
          V,N,SINGLE/V,N,ØMIT/V,N,REACT/V,N,NØSET/V,N,NØL/V,N,NØA $
SAVE      NØGPST,SINCØN,SINGLE,ØMIT,REACT,NØSET,NØL,NØA $
CØND      ERRØR3,NØL $
EQUIV     USETC,USET/SINCØN $
ALTER 62 $
PARAM     //C,N,ADD/V,N,SING/V,Y,SINCØN/C,N,1 $
CØND      ERRØR,SING $
PURGE     KRR,KLR,DM,MLR,MR/REACT /GM/MPCF1 /GØ/ØMIT /KFS/SINGLE /
          QG/NØSET $
```

```
CHKPNT     KRR,KLR,DM,MLR,MR,GM,GØ,KFS,QG,USET $
LABEL      ERROR $
PRTPARM    //C,N,0/C,N,SINCØN $
ENDALTER $
```

Input parameter SINCØN can be changed from the initial value illustrated for the general case, by either using the form C,N,i or by using a PARAM bulk data card with a different value. Note that when SINCØN = -1, the strongest combination of possible singularities is automatically constrained and noted in the GPST output.

6. DIAGNOSTIC MESSAGES

6.1 RIGID FORMAT DIAGNOSTIC MESSAGES

A number of fatal errors are detected by DMAP statements in the various rigid formats. These messages indicate the presence of fatal user errors that, either cannot be determined by the functional modules, or that can be more effectively detected by DMAP statements in the rigid format. The detection of such an error causes a transfer to a LABEL instruction near the end of the rigid format. The text of the message is output and the execution is terminated. These messages will always appear at the end of the NASTRAN output.

6.1.1 Displacement Approach Rigid Formats

The texts of the rigid format error messages are given in the following sections for each of the displacement approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.1.1 Rigid Format Error Messages for Static Analysis

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

An attempt has been made to use more than 360 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1,1.2 Rigid Format Error Messages for Static Analysis with Inertia Relief

NØ. 1 - MASS MATRIX REQUIRED FØR CALCULATIØN ØF INERTIA LØADS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

An attempt has been made to use more than 360 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NØ. 4 - FREE BØDY SUPPØRTS ARE REQUIRED.

A statically determinate set of supports must be specified on a SUPØRT card in order to determine the rigid body characteristics of the structural model.

NØ. 5 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring boundary condition changes was run on subsets 1 or 3. The problem should be restarted on subset 0.

6.1.1.3 Rigid Format Error Messages for Normal Mode Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.4 Rigid Format Error Messages for Static Analysis with Differential Stiffness

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Static Analysis with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 scale factors for differential stiffness calculations. This number may be increased by altering the REPT instruction following SDR1.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 5 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

NO. 6 - A LØØPING PRØBLEM RUN ØN NØN-LØØPING SUBSET.

A problem requiring multiple differential load factor was run on subset (1 or 3) which does not support them. The problem should be restarted on subset 0.

6.1.1.5 Rigid Format Error Messages for Buckling Analysis

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Buckling Analysis. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGB card and METHØD must select an EIGB set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUES FØUND.

No buckling modes exist in the range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.6 Rigid Format Error Messages for Piecewise Linear Analysis

NØ. 1 - NØ NØNLINEAR ELEMENTS HAVE BEEN DEFINED.

A piecewise linear problem has not been formulated because none of the elements have a stress dependent modulus of elasticity defined on a Material card.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

An attempt has been made to use more than 360 load increments. This number may be increased by altering the REPT instruction preceding SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 4 - NØ ELEMENTS HAVE BEEN DEFINED.

The stiffness matrix is null because no elements have been defined on either Connection cards or GENEL cards.

NØ. 5 - STIFFNESS MATRIX SINGULAR DUE TØ MATERIAL PLASTICITY.

The stiffness matrix is singular due either to one or more grid point singularities or element material plasticity.

6.1.1.7 **Rigid Format Error Messages for Direct Complex Eigenvalue Analysis.**

NØ. 1 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR CØMPLEX EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGC card and CMETHØD must select an EIGC set in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following SDR2.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined an a Property card, or the density was not defined on a Material card.

6.1.1.8 **Rigid Format Error Messages for Direct Frequency and Random Response.**

NØ. 1 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the Case Control Deck.

NØ. 2 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must select a dynamic load set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number may be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined on Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.9 Rigid Format Error Message for Direct Transient Response

NØ. 1 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

NØ. 2 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number may be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 3 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

6.1.1.10 Rigid Format Error Messages for Modal Complex Eigenvalue Analysis.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following SDR2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

6.1.1.11 Rigid Format Error Messages for Modal Frequency and Random Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 sets of direct input matrices. This number can be increased by altering the REPT instruction following the last ØFP instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - FREQUENCY RESPØNSE LIST REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Frequencies to be used in the solution of frequency response problems must be supplied on a FREQ, FREQ1, or FREQ2 card and FREQ must select a frequency response set in the the Case Control Deck.

NØ. 6 - DYNAMIC LØADS TABLE REQUIRED FØR FREQUENCY RESPØNSE CALCULATIØNS.

Dynamic loads to be used in the solution of frequency response problems must be specified on an RLØAD1 or RLØAD2 card and DLØAD must selcct a dynamic load set in the Case Control Deck.

6.1.1.12 Rigid Format Error Messages for Modal Transient Response.

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card, or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 dynamic load sets. This number can be increased by altering the REPT instruction following the last XYPLØT instruction.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

NØ. 5 - TRANSIENT RESPØNSE LIST REQUIRED FØR TRANSIENT RESPØNSE CALCULATIØNS.

Time step intervals to be used must be specified on a TSTEP card and a TSTEP selection must be made in the Case Control Deck.

6.1.1.13 Rigid Format Error Messages for Normal Modes with Differential Stiffness.

NØ. 1 - NØ STRUCTURAL ELEMENTS HAVE BEEN DEFINED.

The differential stiffness matrix is null because no structural elements have been defined with Connection cards.

NØ. 2 - FREE BØDY SUPPØRTS NØT ALLØWED.

Free bodies are not allowed in Normal Modes with Differential Stiffness. The SUPØRT cards must be removed from the Bulk Data Deck and other constraints applied if required for stability.

NØ. 3 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 4 - NØ EIGENVALUE FØUND.

No eigenvalues were found in the frequency range specified by the user.

NØ. 5 - MASS MATRIX REQUIRED FØR REAL EIGENVALUE ANALYSIS.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 6 - NØ INDEPENDENT DEGREES ØF FREEDØM HAVE BEEN DEFINED.

Either no degrees of freedom have been defined on GRID, SPØINT or Scalar Connection cards, or all defined degrees of freedom have been constrained by SPC, MPC, SUPØRT, ØMIT, or GRDSET cards, or grounded on Scalar Connection cards.

6.1.1.14 Rigid Format Error Messages for Statics using Cyclic Symmetry.

NØ. 1 - ATTEMPT TØ EXECUTE MØRE THAN 360 LØØPS.

An attempt has been made to use more than 360 different sets of boundary conditions. This number may be increased by altering the REPT instruction following SDR1.

NØ. 2 - MASS MATRIX REQUIRED FØR WEIGHT AND BALANCE CALCULATIØNS.

The mass matrix is null because either no elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

6.1.3 Aero Approach Rigid Formats

The texts of the rigid format error messages are given in the following section for the aero approach rigid formats. The text for each message is given in capital letters and is followed by additional explanatory material, including suggestions for remedial action.

6.1.3.1 Rigid Format Error Messages for Modal Flutter Analysis

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstuctural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 3 - ATTEMPT TØ EXECUTE MØRE THAN 100 LØØPS.

An attempt has been made to use more than 100 different sets of direct input matrices. This number can be increased by altering the REPT instruction following FA2.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

6.1.3.2 Rigid Format Error Messages for Modal Aeroelastic Response

NØ. 1 - MASS MATRIX REQUIRED FØR MØDAL FØRMULATIØN.

The mass matrix is null because either no structural elements were defined with Connection cards, nonstructural mass was not defined on a Property card or the density was not defined on a Material card.

NØ. 2 - EIGENVALUE EXTRACTIØN DATA REQUIRED FØR REAL EIGENVALUE ANALYSIS.

Eigenvalue extraction data must be supplied on an EIGR card and METHØD must select an EIGR set in the Case Control Deck.

NØ. 4 - REAL EIGENVALUES REQUIRED FØR MØDAL FØRMULATIØN.

No real eigenvalues were found in the frequency range specified by the user.

08 *** USER FATAL MESSAGE 8, BULK DATA PARAM CARD ERRØR. MUST NØT DEFINE PARAMETER NAMED ********.

The "N" in V,N,******** means user cannot set the value of the parameter with name ******** on a PARAM card.

09 *** USER FATAL MESSAGE 9, VALUE NEEDED FØR PARAMETER NØ. ***.

Constant needs value in DMAP instruction or on PARAM card.

10 *** USER FATAL MESSAGE 10, ILLEGAL INPUT SECTIØN FØRMAT.

11 *** USER FATAL MESSAGE 11, ILLEGAL ØUTPUT SECTIØN FØRMAT.

12 *** USER FATAL MESSAGE 12, ILLEGAL CHARACTER IN DMAP INSTRUCTIØN NAME.

Name must be 8 or less alpha-numeric characters, the first character being alpha.

13 *** USER FATAL MESSAGE 13, DMAP INSTRUCTIØN NØT IN MØDULE LIBRARY.

14 *** SYSTEM FATAL MESSAGE 14, ARRAY NAMED ******** ØVERFLØWED.

See XGPI module description in MFD section of Programmer's Manual.

15 *** USER FATAL MESSAGE 15, INCØNSISTENT LENGTH USED FØR PARAMETER NAMED ********.

This parameter was used in a previous DMAP instruction which gave it a different type. See Section 5.2.1 of the User's Manual.

16 *** USER FATAL MESSAGE 16, ILLEGAL FØRMAT.

17 *** USER FATAL MESSAGE 17, UNIDENTIFIED NASTRAN CARD KEYWØRD ********. ACCEPTABLE KEYWØRDS FØLLØW ---

18 *** USER FATAL MESSAGE 18, TØØ MANY PARAMETERS IN DMAP PARAMETER LIST.

Incorrect calling sequence for DMAP instruction.

19 *** USER FATAL MESSAGE 19, LABEL NAMED ******** IS MULTIPLY DEFINED.

LABEL named appears in more than one place in DMAP program.

20 *** USER FATAL MESSAGE 20, ILLEGAL CHARACTERS IN PARAMETER NØ. ***.

Name must be 8 or less alpha-numeric characters, the first character being alpha.

21 *** USER FATAL MESSAGE 21, PARAMETER NAMED ******** IS NØT IN PRECEDING DMAP INSTRUCTIØN PARAMETER LIST.

Parameters in SAVE instruction must appear in immediately preceding DMAP instruction.

22 *** USER FATAL MESSAGE 22, DATA BLØCK NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

23 *** USER FATAL MESSAGE 23, DATA BLØCK NAMED ******** IS NØT REFERENCED IN SUBSEQUENT FUNCTIØNAL MØDULE.

See Section 5.2 of the User's Manual. Error can be suppressed by adding the following :

```
PARAM   //C,N,NØP/V,N,TRUE=-1 $
CØND    LABELXXX,TRUE $
TABPT   ********,,,,// $
LABEL   LABELXXX $
```

24 *** SYSTEM FATAL MESSAGE 24, CANNØT FIND FILE NAMED ******** ØN DATA PØØL TAPE.

Contents of /XDPL/ does not match contents of Pool Tape.

25 *** USER FATAL MESSAGE 25, PARAMETER NAMED ******** NØT DEFINED.

Parameter is referenced in nonfunctional module, but is nowhere defined.

26 *** USER FATAL MESSAGE 26, LABEL NAMED ******** NØT DEFINED.

LABEL name does not appear in LABEL instruction.

27 *** USER WARNING MESSAGE 27, LABEL NAMED ******** NØT REFERENCED.

LABEL name appears only in a LABEL instruction.

28 *** SYSTEM FATAL MESSAGE 28, UNEXPECTED END ØF TAPE ØN NEW PRØBLEM TAPE.

Either an EØT was truly encountered or file linkage has been destroyed in /XFIST/, /XPFIST/ and/or /XXFIAT/. This message will also appear when tape files on the NASTRAN Card have been declared disk files but insufficient space has been allocated for this purpose.

29 *** SYSTEM FATAL MESSAGE 29, UNEXPECTED END ØF TAPE ØN ØLD PRØBLEM TAPE.

See Message 28.

30 *** SYSTEM FATAL MESSAGE 30, UNEXPECTED END ØF TAPE ØN DATA PØØL TAPE.

See Message 28.

31 *** SYSTEM FATAL MESSAGE, CØNTRØL FILE ******** INCØMPLETE ØR MISSING ØN NEW PRØBLEM TAPE.

Data block XCSA is not in correct format or it is missing.

32 *** USER FATAL MESSAGE 32, FILE NAMED ******** MUST BE DEFINED PRIØR TØ THIS INSTRUCTIØN.

See Section 5.2 of the User's Manual.

33 *** SYSTEM FATAL MESSAGE 33, NAME (********) IN NEW CØNTRØL FILE DICTIØNARY NØT VALID.

First record of data block XCSA on Problem Tape contains a name which is not recognized by XGPI module.

35 *** USER FATAL MESSAGE 35, INCØRRECT ØLD PRØBLEM TAPE MØUNTED. ID ØF TAPE MØUNTED = ********, ********,**/**/** FILE =***. ID ØF TAPE DESIRED = ********,********,**/**/** FILE =***.

Wrong reel mounted for multireel Problem Tape.

36 *** SYSTEM FATAL MESSAGE 36, CANNØT FIND FILE NAMED ******** ØN ØLD PRØBLEM TAPE.

Header record of file on Problem Tape does not match file name in restart dictionary.

37 *** USER WARNING MESSAGE 37, WARNING ØNLY - MAY NØT BE ENØUGH FILES AVAILABLE FØR MØDULE REQUIREMENTS. FILES NEEDED = *** FILES AVAILABLE = ***.

Program will execute if enough data blocks referenced by the module are purged. Purged data blocks are not assigned files.

38 *** SYSTEM FATAL MESSAGE 38, NØT ENØUGH CØRE FØR GPI TABLES

User must break up DMAP program.

39 *** SYSTEM FATAL MESSAGE 39, RIGID FØRMAT DMAP SEQUENCE DØES NØT CØRRESPØND TØ MED TABLE.

The MED Table must have the same number of entries as there are DMAP instructions in DMAP sequence.

40 *** USER FATAL MESSAGE 40, ERRØR IN ALTER DECK - CANNØT FIND END ØF DMAP INSTRUCTIØN.

User should check ALTER part of the Executive Control Deck.

41 *** SYSTEM FATAL MESSAGE 41, TABLES INCØRRECT FØR REGENERATING DATA BLØCK ********.

File Name Table and MED Table used by routine XFLDEF are wrong.

42 *** USER WARNING MESSAGE 42, PARAMETER NAMED ******** ALREADY HAD VALUE ASSIGNED PREVIØUSLY.

Parameter appears in a previous instruction which assigned it a value. The previous value will be used.

43 *** USER FATAL MESSAGE 43, INCØRRECT FØRMAT FØR NASTRAN CARD.

44 *** USER FATAL MESSAGE 44, UNABLE TØ FIND END DMAP INSTRUCTIØN.

User has altered out the END instruction.

45 *** USER FATAL MESSAGE 45, DATA BLØCK NAMED ******** ALREADY APPEARED AS ØUTPUT ØR WAS USED AS INPUT BEFØRE BEING DEFINED.

See Section 5.2 of the User's Manual.

46 *** USER FATAL MESSAGE 46, INCØRRECT REENTRY PØINT.

The last reentry card in the restart dictionary has a DMAP instruction number greater than the instruction number on the END card of the DMAP program.

47 *** USER FATAL MESSAGE 47, THIS INSTRUCTIØN CANNØT BE FIRST INSTRUCTIØN ØF LØØP.

CHKPNT DMAP instruction must not follow a LABEL instruction which is located at the top of a loop.

48 *** USER WARNING MESSAGE 48, DATA BLØCK ******** IS ALWAYS REGENERATED, THEREFØRE IT WILL NØT BE CHECKPØINTED.

This data block is generated by Input File Processors (IFP) and must not be checkpointed to insure proper restart.

49 *** SYSTEM FATAL MESSAGE 49, MPL TABLE (MØDULE PRØPERTIES LIST) IS INCØRRECT.

Error is in common block /XGPI2/.

50 *** SYSTEM FATAL MESSAGE 50, CANNØT FIND JUMP ØSCAR ENTRY NEEDED FØR THIS RESTART.

There must be a dummy JUMP instruction before every LABEL instruction at top of a loop for rigid formats.

51 *** SYSTEM FATAL MESSAGE 51, NØT ENOUGH ØPEN CØRE FØR XGPIBS RØUTINE.

Additional core memory is required.

52 *** SYSTEM FATAL MESSAGE 52, NAMED CØMMØN /XLINK/ IS TØØ SMALL.

There must be one word in LINK table for every entry in MPL.

53 *** USER FATAL MESSAGE 53, INCØRRECT FØRMAT IN ABØVE CARD.

201 *** USER FATAL MESSAGE 201, REQUESTED BULK DATA DECK ********, NØT ØN USER MASTER FILE.

Requested UMF problem identification number not found on currently mounted UMF tape.

202 *** SYSTEM FATAL MESSAGE 202, UMF CØULD NØT BE ØPENED.

User Master File (UMF) not present (destroyed) in FIST.

203 *** SYSTEM FATAL MESSAGE 203, ILLEGAL EØR ØN UMF.

User Master File (UMF) contains no records in requested file.

204 *** USER FATAL MESSAGE 204, CØLD START, NØ BULK DATA.

No data cards were found after the BEGIN BULK card. A blank card will satisfy this rule.

205 *** USER WARNING MESSAGE 205, CØLD START, DELETE CARDS IGNØRED.

Delete (/) cards were present and ignored within the Bulk Data Deck.

206 *** USER FATAL MESSAGE 206, PREVIØUS ****** CØNTINUATIØN CARDS, THØUGH VALID, CANNØT BE PRØCESSED BECAUSE ØF ERRØRS ØN ØTHER RELATED CØNTINUATIØN CARDS.

207 *** USER INFØ MESSAGE 207, BULK DATA NØT SØRTED, XSØRT WILL REØRDER DECK.

Bulk Data Deck was not in alpha-numeric sort. Sorting will be performed. Sorting of large deck can be time consuming.

208 *** USER FATAL MESSAGE 208, PREVIOUS CARD IS A DUPLICATE PARENT.

Two or more cards were found with column 74-80 identical and a continuation card is present with that mnemonic (column 2-8).

209 *** USER FATAL MESSAGE 209, PREVIØUS ****** CØNTINUATIØN MNEMØNICS HAVE NØ PARENTS AND/ØR ARE DUPLICATES.

This message results due to either or both of the following reasons: (a) one or more cards with continuation mnemonics in columns 2 through 8 could not be matched with any other card continuation mnemonic in columns 73 through 80 or (b) two or more cards with continuation mnemonics in columns 2 through 8 were identical.

210 *** SYSTEM FATAL MESSAGE 210, SCRATCH CØULD NØT BE ØPENED.

One of the required scratch files was not present (destroyed) in FIST.

211 *** SYSTEM FATAL MESSAGE 211, ILLEGAL EØR ØN SCRATCH.

A required scratch file was formatted imporperly.

212 *** SYSTEM FATAL MESSAGE 212, ILLEGAL EØF ØN ITAPE4.

Scratch file containing continuations was mispositioned.

213 *** SYSTEM FATAL MESSAGE 213, ILLEGAL EØF ØN ØPTP.

Old Problem Tape contained no bulk data (illegal format).

214 *** SYSTEM FATAL MESSAGE 214, ØPTP CØULD NØT BE ØPENED.

Old Problem Tape (ØPTP) not present (destroyed) in FIST.

215 *** SYSTEM FATAL MESSAGE 215, NPTP CØULD NØT BE ØPENED.

New Problem Tape (NPTP) not present (destroyed) in FIST.

216 *** SYSTEM FATAL MESSAGE 216, ILLEGAL INDEX.

FORTRAN computed-GØ-TØ has received an illogical value.

217 *** SYSTEM FATAL MESSAGE 217, ILLEGAL EØF ØN ITAPE4.

218 *** USER FATAL MESSAGE 218, ILLEGAL VALUE ØR FØRMAT SPECIFIED IN PARM FIELD.

The core statistics request or the number of bytes to free back to the operating system has not been defined properly on the EXEC statement card. (IBM only.)

300 *** USER FATAL MESSAGE 300, DATA ERRØR IN FIELD UNDERLINED.
(1)
A data error as described in the text has been detected by utility routine XRCARD or RCARD.

300 *** USER FATAL MESSAGE 300, INVALID DATA CØLUMN 72.
(2)
Error in format of exponent.

300 *** USER FATAL MESSAGE 300, INTEGER DATA ØUT ØF MACHINE RANGE.
(3)
The limits are $2^{31}-1$ for IBM, $2^{59}-1$ for CDC and $2^{35}-1$ for UNIVAC.

300 *** USER FATAL MESSAGE 300, INVALID CHARACTER FØLLØWING INTEGER IN CØLUMN ***.
(4)
Either an illegal delimeter was detected or a real number is missing the decimal.

300 *** USER FATAL MESSAGE 300, DATA ERRØR - UNANTICIPATED CHARACTER IN CØLUMN ***.
(5)
A $\pm$ E or $\pm$ D was expected based on other input data.

300 *** USER FATAL MESSAGE 300, DATA ERRØR MISSING DELIMETER ØR REAL PØWER ØUT ØF MACHINE RANGE.
(6)
Either no delimeter was found or the power was exceeded. The limits are E-78 to E+75 for IBM, E-38 to E+38 for UNIVAC and E-294 to E+322 for CDC.

300 *** USER FATAL MESSAGE 300, RØUTINE XRCARD FINDS ØUTPUT BUFFER TØØ SMALL TØ PRØCESS CARD
(7) CØMPLETELY.

301 *** USER WARNING MESSAGE 301, BULK DATA CARD ******** CØNTAINS INCØNSISTENT DATA.
SØRTED CARD CØUNT = ******

302 *** USER WARNING MESSAGE 302, ØNE ØR MØRE GRID CARDS HAVE DISPLACEMENT CØØRDINATE SYSTEM ID ØF -1.

303 *** SYSTEM FATAL MESSAGE 303, NØ ØPEN CØRE FØR IFP.

Overlay structure must be redefined.

304 *** SYSTEM FATAL MESSAGE 304, IFP NØT READING NPTP **** ****.

The Input File Processor subroutine IFP attempts to locate the bulk data file on the NPTP by searching it forward. The first two words of the file header records are examined for a match with the Hollerith string BULKDATA. If the bulk data is not found by the fifth file, the assumption is made that IFP is either not reading NPTP or that it has been badly written. The header record of fifth file is printed as part of the message.

305 *** SYSTEM FATAL MESSAGE 305, GINØ CANNØT ØPEN FILE ******.
Unexpected nonstandard return from ØPEN.

306 *** SYSTEM FATAL MESSAGE 306, READ LØGIC RECØRD ERRØR.
Short record encountered. Bulk data card images occupy 20 words.

307 *** USER FATAL MESSAGE 307, ILLEGAL NAME FØR BULK DATA CARD ******.
See Section 2.4 of the User's Manual.

308 *** USER FATAL MESSAGE 308, CARD ****** NØT ALLØWED IN ****** APPRØACH.
See Section 2.4 of the User's Manual.

309 *** USER WARNING MESSAGE 309, CARD ****** IMPRØPER IN ******** APPRØACH.
See Section 2.4 of the User's Manual.

310 *** USER FATAL MESSAGE 310, CARD ****** NØT ALLØWED IN SAME DECK AS AXIC CARD.
See Section 2.4 of the User's Manual.

311 *** USER FATAL MESSAGE 311, NØNUNIQUE FIELD 2 ØN BULK DATA CARD ******** ***.
Sorted bulk data card indicated must have a unique integer in field 2.

312 *** USER FATAL MESSAGE 312, TØØ MANY CØNTINUATIØNS FØR BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

313 *** USER FATAL MESSAGE 313, ILLEGAL NUMBER ØF WØRDS ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

314 *** SYSTEM FATAL MESSAGE 314, INVALID CALL FRØM IFP ******.
Code error, machine failure, or cell is being destroyed.

315 *** USER FATAL MESSAGE 315, FØRMAT ERRØR ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

316 *** USER FATAL MESSAGE 316, ILLEGAL DATA ØN BULK DATA CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

317 *** USER FATAL MESSAGE 317, BAD DATA ØR FØRMAT ØR NØN-UNIQUE NAME DTI **** SØRTED CARD CØUNT ****.
See bulk data card description in Section 2.4 of the User's Manual.

318 *** SYSTEM FATAL MESSAGE 318, NØ RØØM IN /XDPL/ FØR DTI ****.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

319 *** SYSTEM FATAL MESSAGE 319, IFP READING EØF ØN NPTP.
Unexpected EØF encountered while attempting to read a card image.

320 *** USER FATAL MESSAGE 320, IFP ERRØR ****** LAST CARD PRØCESSED IS ******.
Code error in IFP or XSØRT.

321 *** USER FATAL MESSAGE 321, NØNUNIQUE PARAM NAME *****.
All names of parameters must be unique.

322 *** SYSTEM FATAL MESSAGE 322, ILLEGAL ENTRY TØ IFS1P.
IFP code error detected in IFS1P, IFS2P, IFS3P, IFS4P, IFS5P.

324 *** USER WARNING MESSAGE 324, BLANK CARD(S) IGNØRED.
Blank bulk data cards are ignored by NASTRAN.

325 *** USER FATAL MESSAGE 325, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMI ******.
See bulk data card description in Section 2.4 of the User's Manual.

326 *** SYSTEM FATAL MESSAGE 326, NØ RØØM IN /XDPL/ FØR DMI ******.
Overflow of Data Pool Table. See Section 2 of the Programmer's Manual.

327 *** USER FATAL MESSAGE 327, BAD DATA ØR FØRMAT ØR NØNUNIQUE NAME. DMIG ******.
See bulk data card description in Section 2.4 of the User's Manual.

328 *** SYSTEM FATAL MESSAGE 328, ILLEGAL ENTRY TØ IFS3P.
IFP code error.

329 *** USER FATAL MESSAGE 329, ØNLY ØNE (1) AXIC CARD ALLØWED.
See bulk data card description in Section 2.4 of the User's Manual.

330 *** SYSTEM FATAL MESSAGE 330, NØ RØØM IN CØRE FØR PARAM CARDS.
Change overlay or increase core size.

331 *** USER FATAL MESSAGE 331, IMPRØPER PARAM CARD ******.
See bulk data card description in Section 2.4 of the User's Manual.

332 *** USER FATAL MESSAGE 332, AXIC CARD REQUIRED.
The presence of any conical shell data cards requires the presence of an AXIC card.
See the AXIC bulk data card description in Section 2.4 of the User's Manual.

333 *** USER FATAL MESSAGE 333, UNABLE TØ SØRT ******** MULTI-ENTRY CARD DATA IN SUBRØUTINE IFP DUE TØ INSUFFICIENT CØRE.
ADDITIØNAL CØRE REQUIRED = ********** WØRDS.

Either increase the core or manually sort multi-entry data cards (CRØD, CTUBE, etc.)

334 *** USER INFØRMATIØN MESSAGE 334, ******** MULTI-ENTRY CARD DATA ARE NØT SØRTED ØN THEIR ELEMENT ID's. SUBRØUTINE IFP WILL SØRT THE DATA.

335 *** USER FATAL MESSAGE 335, NØN-UNIQUE ELEMENT ID ******** ENCØUNTERED IN ******** MULTI-ENTRY CARD DATA.

Element identification numbers in multi-entry bulk data cards (CRØD, CTUBE, etc.) must be unique integers.

336 *** USER FATAL MESSAGE 336, RFØRCE DATA IN SET NØ. ******** CØNTAINS ILLEGAL DIRECTIØN FØR AXISYMMETRIC PRØBLEM.

Only the z component of the rotation direction vector can be defined. See the RFØRCE data card description for details.

501 *** SYSTEM FATAL MESSAGE 501, MED TABLE INCØRRECT FØR THIS SØLUTIØN.

Input to subroutine XSBET is incorrect. Look for format error in array SS.

502 *** USER FATAL MESSAGE 502, ILLEGAL SUBSET NUMBER FØR THIS SØLUTIØN.

User specified an incorrect subset number on SØL control card.

503 *** USER FATAL MESSAGE 503, ILLEGAL SØLUTIØN NUMBER.

User specified an incorrect solution number on SØL control card.

504 *** USER FATAL MESSAGE 504, CANNØT CHANGE FRØM SØLUTIØN *** TØ SØLUTIØN ***.

505 *** USER FATAL MESSAGE 505, CØNTRØL CARD **** IS ILLEGAL.

Card preceding Message 505 cannot be processed correctly.

506 *** USER FATAL MESSAGE 506, CONTROL CARD **** DUPLICATED.

Card preceding Message 506 cannot be input more than once.

507 *** USER FATAL MESSAGE 507, ILLEGAL SPECIFICATIØN ØR FØRMAT ØN PRECEDING CARD.

508 *** USER FATAL MESSAGE 508, PRØBLEM TAPE MUST BE ØN PHYSICAL TAPE FØR CHECKPØINTING.

User requested checkpointing (i.e., CHKPNT YES) therefore Problem Tape must be setup on tape drive.

509 *** USER FATAL MESSAGE 509, WRØNG ØLD PRØBLEM TAPE MØUNTED. ØLD PRØBLEM TAPE ID = ********, ********,**/**/**, REEL NØ. = ***.

The Old Problem Tape identification does not match the identification on the RESTART restart card.

510 *** SYSTEM FATAL MESSAGE 510, CHECKPØINT DICTIØNARY EXCEEDS CØRE SIZE - REMAINING RESTART CARDS IGNØRED.

You have run out of open core. If approach is DMAP try putting restart deck before DMAP sequence. If this does no' solve problem, or if approach is not DMAP, then you must decrease size of restart deck.

511 *** SYSTEM FATAL MESSAGE 511, DMAP SEQUENCE EXCEEDS CØRE SIZE - REMAINING DMAP INSTRUCTIØNS IGNØRED.

You have run out of open core. Split the DMAP sequence somewhere prior to where message 511 was printed out.

512 *** USER FATAL MESSAGE 512, ØLD PRØBLEM TAPE IS MISSING AND IS NEEDED FØR RESTART.

The Problem Tape corresponding to identification on RESTART control card must be setup on the unit assigned to the Old Problem Tape.

513 *** USER FATAL MESSAGE 513, ALTER SEQUENCE NUMBERS ARE ØUT ØF ØRDER.

514 *** USER FATAL MESSAGE 514, ENDALTER CARD IS MISSING.

Alter deck must end with ENDALTER control card.

515 *** USER FATAL MESSAGE 515, END INSTRUCTIØN MISSING IN DMAP SEQUENCE.

DMAP sequence must end with END control card.

516 *** USER FATAL MESSAGE 516, UMF TAPE MUST BE MØUNTED ØN PHYSICAL TAPE DRIVE.

The UMF tape must be setup on the unit assigned to it.

517 *** USER FATAL MESSAGE 517, WRØNG UMF TAPE MØUNTED - TAPE ID = ****.

The tape identification number on the UMF tape does not match the tape identification number on the UMF control card.

518 *** USER FATAL MESSAGE 518, CANNØT USE UMF TAPE FØR RESTART.

519 *** USER FATAL MESSAGE 519, ID CARD MUST PRECEDE ALL ØTHER CØNTRØL CARDS.

520 *** USER FATAL MESSAGE 520, CØNTRØL CARD **** IS MISSING.

The control card mentioned is required for this problem.

521 *** USER FATAL MESSAGE 521, SPECIFY A SØLUTIØN ØR A DMAP SEQUENCE BUT NØT BØTH.

You must either select a DMAP sequence from the library by using the SØL control card or by supplying your own DMAP sequence. Do one or the other, but not both.

522 *** USER FATAL MESSAGE 522, NEITHER A SØL CARD NØR A DMAP SEQUENCE WAS INCLUDED.

See Message 521.

523 *** USER FATAL MESSAGE 523, ENDALTER CARD ØUT ØF ØRDER.

ENDALTER control card must be preceded by the ALTER DECK.

524 *** SYSTEM FATAL MESSAGE 524, ALTERNATE RETURN TAKEN WHEN ØPENING FILE ****.

This occurs if file name is not in FIST or the end of tape was reached while writing on the file. The file name should correspond to one of the permanent entries in the FIST.

525 *** SYSTEM FATAL MESSAGE 525, ILLEGAL FØRMAT ENCØUNTERED WHILE READING FILE ****.

File is not in the correct format. Either the wrong tape was mounted or it does not contain what you think it should.

526 *** USER FATAL MESSAGE 526, CHECKPØINT DICTIØNARY ØUT ØF SEQUENCE - REMAINING RESTART CARDS IGNØRED.

The checkpoint dictionary which follows the RESTART control card must be sequenced according to first number on each card.

527 *** USER FATAL MESSAGE 527, DUPLICATE SUBSET NUMBER *****.

601 *** USER FATAL MESSAGE 601, THE KEYWØRD ØN THE ABØVE CARD IS ILLEGAL ØR MISSPELLED. SEE THE FØLLØWING LIST FØR LEGAL KEY WØRDS.

Case control expects each card to begin with a keyword (usually 4 characters in length). Your card does not. User Message 612 will list the legal keywords along with a brief description of function. To remove the error, consult Message 612 of NASTRAN case control card descriptions, User's Manual Section 2.3, and spell your request correctly.

602 *** USER WARNING MESSAGE 602, TWØ ØR MØRE ØF THE ABØVE CARD TYPES DETECTED WHERE ONLY ØNE IS LEGAL. THE LAST FØUND WILL BE USED.

Remove the card with the duplicate meaning. Note that some cards have alternate forms.

603 *** USER FATAL MESSAGE 603, THE ABØVE CARD DØES NØT END PRØPERLY. CØMMENTS SHØULD BE PRECEDED BY A DØLLAR SIGN.

Case control cards of the form, name = value, should not contain more than one value. Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for a complete description of the card or precede your comments with a dollar sign.

604 *** USER FATAL MESSAGE 604, THE ABØVE CARD HAS A NØNINTEGER IN AN INTEGER FIELD.

Consult your NASTRAN Case Control Deck document, User's Manual Section 2.3, for legal values.

605 *** USER FATAL MESSAGE 605, A SYMSEQ OR SUBSEQ CARD APPEARS WITHØUT A SYMCØM ØR SUBCØM CARD.

SYMSEQ or SUBSEQ cards must appear in a subcase defined by a SYMCØM or SUBCØM card. Check your Case Control Deck order and relabel your combination subcase.

606 *** USER FATAL MESSAGE 606, A REQUEST FØR TEMPERATURE DEPENDENT MATERIALS ØCCURS AT THE SUBCASE LEVEL. ØNLY ØNE ALLOWED PER PRØBLEM.

Only one temperature field for materials is allowed per NASTRAN run. The last specified will be used for the entire run. If additional ones are desired, a modified restart is in order.

607 *** USER FATAL MESSAGE 607, A REPCASE SUBCASE MUST BE PRECEDED BY A SUBCASE ØR SYM SUBCASE.

A REPCASE subcase is an attempt to reoutput the previously computed case, therefore it cannot be the first subcase.

608 *** USER FATAL MESSAGE 608, THE SET ID SPECIFIED ØN THE ABØVE CARD MUST BE DEFINED PRIØR TO THIS CARD.

Set identification numbers must be specified prior to their use. Also sets specified within a subcase die at the end of the subcase. Redefine set (or define set) or move set out of subcase.

609 *** USER FATAL MESSAGE 609, SUBCASE DELIMITER CARDS MUST HAVE A UNIQUE IDENTIFYING INTEGER.

Subcase type cards must have an identifying integer. These numbers must be strictly increasing. Renumber your subcase cards. The use of a nonblank delimiter (e.g., "=") will also cause this message to occur.

610 *** USER FATAL MESSAGE 610, THE VALUE FØLLØWING THE EQUAL SIGN IS ILLEGAL.

Case control cannot identify the BCD value after the equal sign. Consult NASTRAN case control card descriptions, User's Manual Section 2.3, for a full description of the card.

611 *** USER FATAL MESSAGE 611, TEN CARDS HAVE ILLEGAL KEY WØRDS. NASTRAN ASSUMES BEGIN BULK CARD IS MISSING. IT WILL NØW PRØCESS YØUR BULK DATA.

Only ten key words may be misspelled. A common source of this error may be the omission of the ØUTPUT(PLØT) or ØUTPUT(XYØUT) delimiter cards.

612 *** USER FATAL MESSAGE 612, --LIST OF LEGAL CASE CØNTROL MNEMØNICS.

This message is caused by Messages 601 or 611.

613 *** USER FATAL MESSAGE 613, THE ABØVE SET CØNTAINS 'EXCEPT' WHICH IS NØT PRECEDED BY 'THRU'.

Only identification numbers included in THRU statements may be excepted. Simplify your SET request.

614 *** USER FATAL MESSAGE 614, THE ABØVE SET IS BADLY SPECIFIED.

The grammar of the SET list is so confused that IFP1 cannot continue. Simplify the SET list.

615 *** USER FATAL MESSAGE 615, AN IMPRØPER ØR NØ NAME GIVEN TØ THE ABØVE SET.

SET lists must have integer names. This SET list does not have one. SET 10 = is the correct format. Give the SET a correct integer name.

616 *** USER FATAL MESSAGE 616, 'EXCEPT' CANNOT BE FØLLØWED BY 'THRU'. LIST EXPLICITLY ALL EXCEPTIØNS.

EXCEPT in SET list can only be followed by integers. An integer larger than THRU pair terminates THRU. Either list exceptions explicitly, use 2 'THRU's or terminate first THRU.

617 *** USER FATAL MESSAGE 617, A NØNPØSITIVE INTEGER APPEARS IN A PØSITIVE PØSITIØN.

Most integer values in case control must be positive. The above card either has a negative integer or a BCD value in a positive position. Check the Case Control Deck documentation in Section 2.3 of the User's Manual for the proper card format.

618 *** USER FATAL MESSAGE 618, PLØTTER ØUTPUT IS REQUESTED BUT NØ PLØT TAPE IS SET UP.

Neither PLT1 or PLT2 is a physical tape. Remove the plot control packet or set up the appropriate tape.

619 *** USER WARNING MESSAGE 619, SET MEMBER *** BELØNGS TØ *** THRU ***.

A set member is already included in a THRU. The individual member will be absorbed in the THRU.

620 *** USER WARNING MESSAGE 620, DUPLICATE *** IS IN SET LIST.

A set member is listed twice. The second reference will be deleted.

621 *** USER WARNING MESSAGE 621, INTERVAL *** THRU *** ØVERLAPS INTERVAL *** THRU ***. THE MAXIMUM INTERVAL WILL BE USED.

625 *** USER FATAL MESSAGE 625, SUBCASE ID'S MUST BE LESS THAN 99,999,999.

Reduce the size of your subcase identification number. Note also that BCD subcase identification numbers are not legal.

626 *** USER FATAL MESSAGE 626, SUBCØM SUBCASE DØES NØT HAVE A SUBSEQ CARD.

A SUBCØM SUBCASE must contain a SUBSEQ card to define the linear combination coefficients.

627 *** USER FATAL MESSAGE 627, THE ABØVE SUBCASE HAS BØTH A STATIC LØAD AND A REAL EIGENVALUE METHØD SELECTIØN -- REMØVE ØNE.

Rigid Formats 5 and 13 require a static load and method selection in the Case Control Deck. Both a load and a method selection cannot take place in the same subcase. See Sections 3.6.4 and 3.14.4, respectively, for subcase requirements.

628 *** USER FATAL MESSAGE 628, THERMAL, DEFØRMATIØN, AND EXTERNAL LØADS CANNØT HAVE THE SAME SET IDENTIFICATIØN NUMBER.

Set id's specified on the LØAD, TEMP (LØAD), and DEFØRM Case Control Cards must be unique.

629 *** USER WARNING MESSAGE 629, ECHØ CARD HAS REPEATED ØR UNRECØGNIZABLE SPECIFICATIØN DATA-REPEATED SPECIFICATIØNS WILL BE IGNØRED, UNRECØGNIZABLE SPECIFICATIØNS WILL BE TREATED AS SØRT.

630 *** USER WARNING MESSAGE 630, ECHØ CARD WITH -NØNE- SPECIFICATIØN HAS ADDITIØNAL SPECIFICATIØNS WHICH WILL BE IGNØRED.

675 *** USER FATAL MESSAGE 675, ABØVE CARD DØES NØT BEGIN WITH A NØNNUMERIC WØRD.

676 *** USER FATAL MESSAGE 676, **** IS NØT RECØGNIZED ØN ABØVE CARD.

677 *** USER FATAL MESSAGE 677, ILLEGAL VALUE SPECIFIED.

678 *** USER FATAL MESSAGE 678, *** CØNTRADICTS PREVIOUS DEFINITIØN.

679 *** USER FATAL MESSAGE 679, *** DELIMETER ILLEGALLY USED.

680 *** USER FATAL MESSAGE 680, **** ILLEGAL IN STATEMENT.

681 *** USER FATAL MESSAGE 681, **** IS ILLEGAL IN STATEMENT.

682 *** USER FATAL MESSAGE 682, **** IS ILLEGAL IN STATEMENT.

683 *** USER FATAL MESSAGE 683, TØØ MANY SUBCASES. MAXIMUM = 200 ØN ANY ØNE XY-ØUTPUT CØMMAND CARD.

684 *** USER FATAL MESSAGE 684, SUBCASE-ID IS LESS THAN 1 ØR IS NØT IN ASCENDING ØRDER.

685 *** USER FATAL MESSAGE 685, **** = PØINT ØR ELEMENT ID IS ILLEGAL (LESS THAN 1).

686 *** USER FATAL MESSAGE 686, NEGATIVE ØR ZERØ CØMPØNENTS ARE ILLEGAL.

687 *** USER FATAL MESSAGE 687, ALPHA-CØMPØNENTS ARE NØT PERMITTED FØR STRESS ØR FØRCE XY-ØUTPUT REQUESTS.

An XYPLØT command for stresses and forces cannot have alphabetic characters in the item code. See the tables in Section 4.3.3 for the proper format.

688 *** USER FATAL MESSAGE 688, **** CØMPØNENT NAME NØT RECØGNIZED.

689 *** USER FATAL MESSAGE 689, LAST CARD ENDED WITH A DELIMETER BUT NØ CØNTINUATIØN CARD WAS PRESENT.

690 *** USER FATAL MESSAGE 690, TYPE ØF CURVE WAS NØT SPECIFIED. (E.G., DISPLACEMENT, STRESS, ETC.)

691 *** USER FATAL MESSAGE 691, MØRE THAN 2 ØR UNEQUAL NUMBER ØF CØMPØNENTS FØR IDENTIFICATIØN NUMBERS WITHIN A SINGLE FRAME.

692 *** USER FATAL MESSAGE 692, XY-ØUTPUT CØMMAND IS INCØMPLETE.

693 *** USER FATAL MESSAGE 693, INSUFFICIENT CØRE FØR SET TABLE.

694 *** USER FATAL MESSAGE 694, AUTØ ØR PSDF REQUESTS MAY NØT USE SPLIT FRAME, THUS ØNLY ØNE CØMPØNENT PER ID IS PERMITTED.

695 *** USER FATAL MESSAGE 695, CØMPØNENT VALUE = **** IS ILLEGAL FØR AUTØ ØR PSDF VECTØR REQUESTS.

696 *** USER FATAL MESSAGE 696, CØMPØNENT VALUE = ******** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

969 *** USER FATAL MESSAGE 969, COMPONENT VALUE = **** IS ILLEGAL FØR VECTØR TYPE SPECIFIED.

975 *** USER WARNING MESSAGE 975, XYTRAN DØES NØT RECØGNIZE **** AND IS IGNØRING.

976 *** USER WARNING MESSAGE 976, ØUTPUT DATA BLØCK **** IS PURGED. XYTRAN WILL PRØCESS ALL REQUESTS ØTHER THAN PLØT.

977 *** USER WARNING MESSAGE 977, FØLLØWING NAMED DATA BLØCK IS NØT IN SØRT2 FØRMAT.

978 *** USER WARNING MESSAGE 978, XYTRAN MØDULE FINDS DATA BLØCK (****) PURGED, NULL, ØR INADEQUATE, AND IS IGNØRING XY-ØUTPUT REQUEST FØR - **** - CURVES.

979 *** USER WARNING MESSAGE 979, AN XY-ØUTPUT REQUEST FØR PØINT ØR ELEMENT ID **** - **** - CURVE IS BEING PASSED ØVER. THE ID CØULD NØT BE FØUND IN DATA BLØCK ****.

980 *** USER WARNING MESSAGE 980, INSUFFICIENT CØRE TØ HANDLE ALL DATA FØR ALL CURVES ØF THIS FRAME ID = **** CØMPØNENT = **** DELETED FRØM ØUTPUT.

981 *** USER WARNING MESSAGE 981, CØMPØNENT = **** FØR ID = **** IS TØØ LARGE. THIS CØMPØNENTS CURVE NØT ØUTPUT.

982 *** USER WARNING MESSAGE 982, FØRMAT ØF SDR3 INPUT DATA BLØCK **** DØES NØT PERMIT SUCCESSFUL SØRT2 PRØCESSING.

983 *** USER WARNING MESSAGE 983, SDR3 HAS INSUFFICIENT CØRE TØ PERFØRM SØRT2 ØN INPUT DATA BLØCK **** ØR DATA BLØCK IS NØT IN CØRRECT FØRMAT.

984 *** USER WARNING MESSAGE 984, SDR3 FINDS ØUTPUT DATA BLØCK **** PURGED.

985 *** USER WARNING MESSAGE 985, SDR3 FINDS SCRATCH **** PURGED.

986 *** USER WARNING MESSAGE 986, INSUFFICIENT CØRE FØR SDR3.

991 *** USER WARNING MESSAGE 991, XYPLØT INPUT DATA FILE **** NØT FØUND. XYPLØT ABANDØNED.

The input data file probably has been purged and there were no plots to be done.

992 *** USER WARNING MESSAGE 992, XYPLØT INPUT DATA FILE I.D. RECØRDS TØØ SHØRT. XYPLØT ABANDØNED.

The input data file records have invalid word counts and further plotting is not feasible.

993 *** USER WARNING MESSAGE 993, XYPLØT FØUND ØDD NØ. ØF VALUES FØR DATA PAIRS IN FRAME ****, CURVE NØ. ****. LAST VALUE IGNØRED.

May indicate a bad input file, but plotting continues.

994 *** USER WARNING MESSAGE 994, XYPLØT ØUTPUT FILE NAME **** NØT FØUND. XYPLØT ABANDØNED.

A magnetic tape for plotting has not been properly set up and further plotting is useless.

995 *** USER WARNING MESSAGE 995, XYPLØT HAS ILLEGAL PLØTTER NUMBER = **** FRØM INPUT DATA FILE. PLØTTER NØ. **** ASSUMED.

Probable cause is the user not setting up the proper plotter number in the Case Control Deck. The plotting will be done on the plotter most commonly used at the installation.

996 *** USER WARNING MESSAGE 996, SPECIFIED PLØTTER PAPER SIZE TØØ SMALL. XYPLØT ASSUMES DIMENSIØN IS 8 INCHES.

Message is for table plotter only. Assumption is made that plotter paper will be at least as large as stated. In any event the table plotter will have an inch margin on all sides.

997 *** USER WARNING MESSAGE 997, NØ. ***. FRAME NØ. **** INPUT DATA INCØMPATIBLE. ASSUMPTIØNS MAY PRODUCE INVALID PLØT.

NØ. *** may take any value from 1 to 4 with the following meaning:

1. Specified X maximum equal X minimum. If this value is zero, then X maximum is set to 5.0 and X minimum to -5.0, otherwise 5 times the absolute value of X maximum is added to X maximum and subtracted from X minimum.
2. Specified X maximum is smaller than X minimum. The values are reversed.
3. Same meaning as number 1 except for Y maximum and Y minimum.
4. Same meaning as number 2 except for Y maximum and Y minimum.

998 *** SYSTEM WARNING MESSAGE 998, XYPLØT PLØTTER ØR FRAME MAY NØT CHANGE FØR LØWER FRAME. XYPLØT ABANDØNED.

Camera option, size of paper, and plotter type must be the same for upper and lower frames.

1150 *** SYSTEM FATAL MESSAGE 1150, RECTYP MUST BE CALLED WHEN THE FILE IS PØSITIØNED AT THE BEGINNING ØF A RECØRD.

1151 *** SYSTEM FATAL MESSAGE 1151, ØN A CALL TØ ØPEN THE BUFFER ASSIGNED ØVERLAPS A PREVIØUSLY ASSIGNED BUFFER.

1152 *** SYSTEM FATAL MESSAGE 1152, CALL TØ ØPEN FØR AN ALREADY ØPEN FILE.

1153 *** SYSTEM FATAL MESSAGE 1153, FILE NØT ØPEN.

1154 *** SYSTEM FATAL MESSAGE 1154, GINØ REFERENCE NAME NØT IN FIST ØR FILE NØT ØPEN.

1155 *** SYSTEM FATAL MESSAGE 1155, CALL TØ GETSTR ØCCURRED WHEN THE FILE WAS PØSITIØNED AT END-ØF-FILE.

1156 *** SYSTEM FATAL MESSAGE 1156, ATTEMPTED TØ WRITE ØN AN INPUT FILE.

1157 *** SYSTEM FATAL MESSAGE 1157, ATTEMPTED TØ READ FRØM AN ØUTPUT FILE.

1158 *** SYSTEM FATAL MESSAGE 1158, A CALL TØ BLDPK ØR PACK IN WHICH EITHER TYPIN ØR TYPØUT IS ØUT ØF RANGE.

1159 *** SYSTEM FATAL MESSAGE 1159, RØW PØSITIØNS ØF ELEMENTS FURNISHED TØ ZBLPKI ØR BLDPKI ARE NØT IN MØNØTØNIC INCREASING SEQUENCE.

1160 *** SYSTEM FATAL MESSAGE 1160, ØN A CALL TØ BLDPKN, FILE NAME DØES NØT MATCH PREVIØUS CALLS.

BLDPK was not called prior to call to BLDPKN.

1161 *** SYSTEM FATAL MESSAGE 1161, A CALL TØ INTPK ØR UNPACK IN WHICH TYPØUT IS ØUT ØF RANGE.

1162 *** SYSTEM FATAL MESSAGE 1162, ØN AN ATTEMPT TØ READ A SUBINDEX AT THE TIME ØF A CALL TØ ØPEN AN END-ØF-FILE WAS ENCØUNTERED ØR WRØNG NUMBER ØF WØRDS READ.

The file has never been written and IØ6600 failed to detect it; possible I/Ø error.

1163 *** SYSTEM FATAL MESSAGE 1163, A READ ATTEMPT WHEN THE CØRRESPØNDING SUBINDEX IS ZERØ

Normally this indicates an attempt to read past the end-of-information. However, if called from FILPØS, suspect is subroutine error in saving and returning a correct file position.

1164 *** SYSTEM FATAL MESSAGE 1164, FØLLØWING A READ ATTEMPT ON AN INDEXED FILE, EITHER AN END-ØF-FILE WAS ENCØUNTERED ØR THE NUMBER ØF WØRDS READ WAS INCØRRECT.

I/Ø error.

1165 *** SYSTEM FATAL MESSAGE 1165, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE, AN END-ØF-FILE ØR AN END-ØF-INFØRMATIØN WAS ENCØUNTERED.

1166 *** SYSTEM FATAL MESSAGE 1166, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE, A LØNG RECØRD WAS ENCØUNTERED.

1167 *** SYSTEM FATAL MESSAGE 1167, ØN AN ATTEMPT TØ READ A SEQUENTIAL FILE A SHØRT RECØRD WAS ENCØUNTERED.

1168 *** SYSTEM FATAL MESSAGE 1168, A CALL TØ IØ6600 WITH ØPCØDE=5 (FØRWARD SPACE) IS NØT SUPPØRTED.

1169 *** SYSTEM FATAL MESSAGE 1169, ILLEGAL CALL TYPE, LØGIC ERRØR IN IØ6600.

1170 *** SYSTEM FATAL MESSAGE 1170, ILLEGAL CALL TØ NASTIØ, LØGIC ERRØR IN IØ6600.

1171 *** SYSTEM FATAL MESSAGE 1171, ØN A PØSITIØN CALL, THE BLØCK NUMBER REQUESTED IS NØT FØUND IN CØRE WHEN IT IS EXPECTED THERE.

Either the caller has written in the area furnished to NASTIØ or there is a logic error in NASTIØ.

1172 *** SYSTEM FATAL MESSAGE 1172, WHEN ATTEMPTING TØ READ A NEW INDEX, THE NUMBER ØF WØRDS RETURNED WAS INCØRRECT.

Either an I/Ø error or logic error in NASTIØ.

1201 *** SYSTEM FATAL MESSAGE 1201, FIAT ØVERFLØW.

FIAT /XFIAT/ overflowed - reduce number of logical files. See Section 2.4 of the Programmer's Manual.

1202 *** SYSTEM FATAL MESSAGE 1202, DPL ØVERFLØW.

Data Pool Dictionary /XDPL/ overflowed - increase compiled size. See Section 2.4 of the Programmer's Manual.

1300 *** SYSTEM FATAL MESSAGE 1300, END-ØF-FILE WAS CALLED ØN A FILE ØPEN FØR INPUT.

1301 *** SYSTEM FATAL MESSAGE 1301, END-ØF-FILE ENCØUNTERED.

An error in the calling program caused an unexpected end-of-file.

1302 *** SYSTEM FATAL MESSAGE 1302, ZERØ LENGTH RECØRD SEGMENT ENCØUNTERED.

A zero length record segment occurred before the last record in a block.

1303 *** SYSTEM FATAL MESSAGE 1303, ATTEMPT TO GET A STRING PRIØR TØ INFØRMATIØN.

There is an error in the calling program.

1304 *** SYSTEM FATAL MESSAGE 1304, UNRECØGNIZED CØNTRØL WØRD.

The calling program may have overwritten a buffer.

1305 *** SYSTEM FATAL MESSAGE 1305, BLØCK NUMBER CHECK FAILED.

In the process of making a data block core resident, the block number did not have the expected value.

1306 *** SYSTEM FATAL MESSAGE 1306, BLØCK NUMBER IN BLØCK TØ BE WRITTEN DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1307 *** SYSTEM FATAL MESSAGE 1307, BLØCK NUMBER ØF BLØCK TØ BE WRITTEN IS NØT IN CURRENT UNIT.

The block number was not in the current unit and not equal to the block number in the preceeding unit.

1308 *** SYSTEM FATAL MESSAGE 1308, ATTEMPT TØ READ BEYØND DATA.

1309 *** SYSTEM FATAL MESSAGE 1309, CØRE RESIDENT DATA BLØCK NUMBER DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1310 *** SYSTEM FATAL MESSAGE 1310, PØINTER TØ NEXT CØRE RESIDENT DATA BLØCK IS ZERØ.

Next block should be in core.

1311 *** SYSTEM FATAL MESSAGE 1311, BLØCK NUMBER TØ BE READ IS NØT INCLUDED IN CURRENT CHAIN ØF UNITS.

1312 *** SYSTEM FATAL MESSAGE 1312, BLØCK NUMBER OF BLØCK READ FRØM DISK DØES NØT MATCH NUMBER IN FILE CØNTRØL BLØCK.

1313 *** SYSTEM FATAL MESSAGE 1313, PØINTER TØ CØRE RESIDENT DATA BLØCK IS PØSITIØNED PRIØR TØ INFØRMATIØN.

1314 *** SYSTEM FATAL MESSAGE 1314, ATTEMPT TØ PØSITIØN A FILE ØPENED TØ WRITE.

1315 *** SYSTEM FATAL MESSAGE 1315, BLØCK NUMBER NØT FØUND.

Logic error in an attempt to position a core resident data block.

1316 *** SYSTEM FATAL MESSAGE 1316, NØ DATA EVENT CØNTRØL BLØCK AVAILABLE.

1317 *** SYSTEM FATAL MESSAGE 1317, ERRØR IN INTERNAL SUBRØUTINE IN NASTIØ.

1318 *** SYSTEM FATAL MESSAGE 1318, ATTEMPT TØ READ BEYØND END-ØF-DATA.

1319 *** SYSTEM FATAL MESSAGE 1319, DCB SYNCHRØNØUS ERRØR DETECTED.

Data control block improperly written.

1320 *** SYSTEM FATAL MESSAGE 1320, FIRST TERM IN RØW IS NØT A DIAGØNAL TERM.

1321 *** SYSTEM FATAL MESSAGE 1321, FIRST TERM IN RØW IS NØT A DIAGØNAL TERM.

1322 *** SYSTEM FATAL MESSAGE 1322, BAD STATUS RETURN ØN A NTRAN READ CALL.

Possible I/Ø error.

1323 *** SYSTEM FATAL MESSAGE 1323, END-ØF-DATA ENCØUNTERED.

The unit on which the end-of-data occurred is not a tape.

1324 *** SYSTEM FATAL MESSAGE 1324, INCØRRECT WØRD CØUNT ØN A NTRAN READ CALL.

Number of words read by NTRAN is incorrect.

1325 *** SYSTEM FATAL MESSAGE 1325, BAD STATUS RETURN ØN A NTRAN WRITE CALL.

Possible I/Ø error.

1326 *** SYSTEM FATAL MESSAGE 1326, INCØRRECT NUMBER ØF WØRDS PASSED BY NTRAN.

1327 *** SYSTEM FATAL MESSAGE 1327, ILLEGAL RETURN FRØM FWDREC.

1701 *** SYSTEM WARNING MESSAGE 1701, AVAILABLE CØRE EXCEEDED BY ********* LINE IMAGE BLØCKS.

1702 *** SYSTEM INFØRMATIØN MESSAGE 1702, UTILITY MØDULE SEEMAT WILL ABANDØN PRØCESSING DATA BLØCK ********.

1703 *** USER WARNING MESSAGE 1703, ILLEGAL PLØTTER SPECIFIED FØR SEEMAT (********).

1704 *** USER WARNING MESSAGE 1704, PLØT FILE - **** NØT SET UP.

1705 *** USER WARNING MESSAGE 1705, LØGIC ERRØR AT STATEMENT ***** IN SUBRØUTINE SEEMAT.

1706 *** USER WARNING MESSAGE 1706, PRECEDING BULK DATA DECK HAS BEEN CANCELED AND WILL NØT APPEAR ØN USER MASTER FILE.

The preceding Bulk Data Deck contains errors which preclude its inclusion on the User Master File. Appropriate error messages should appear in the echo of the Bulk Data Deck. Any subsequent Bulk Data Decks will be placed on the User Master File if error-free.

1707 *** USER FATAL MESSAGE 1707, ILLEGAL TID VALUE ØN UMF CARD.

The TID value used on all UMF cards must be the same for any run and must match the TID value on the UMF tape being input. See Section 2.5 of the User's Manual for details.

1708 *** SYSTEM FATAL MESSAGE 1708, UMFEDT - UNEXPECTED EØF FROM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1709 *** SYSTEM FATAL MESSAGE 1709, UMFEDT - UNEXPECTED EØR FRØM READ.

The occurence of this message indicates a program failure in the User Master File Editor subroutine UMFEDT.

1710 *** SYSTEM FATAL MESSAGE 1710, UMFEDT UNABLE TØ ØPEN ØNE ØF THE PERMANENT NASTRAN FILES UMF, NUMF, ØR NPTP.

1711 *** USER FATAL MESSAGE 1711, NØ TAPE SETUP FØR EITHER UMF ØR NUMF. THE USER MASTER FILE EDITØR REQUIRES AT LEAST ØNE ØF THESE TAPES TØ BE SET UP.

The tape(s) required must be appropriate to the requested action. See Section 2.5 of the User's Manual for details.

1712 *** USER WARNING MESSAGE 1712, REQUEST TØ ADD DECK WITH PRØBLEM IDENTIFICATION NØ. = **** CØNFLICTS WITH IMPLIED REQUEST TØ CØPY THE SAME PRØBLEM FRØM THE UMF. THE NEW DECK WILL BE USED.

This message will occur whenever a deck is added whose PID value is the same as that of a problem already existing on the old User Master File.

1713 *** USER WARNING MESSAGE 1713, REMØVE REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1714 *** USER WARNING MESSAGE 1714, LIST REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1715 *** USER WARNING MESSAGE 1715, PUNCH REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1716 *** USER FATAL MESSAGE 1716, PRØBLEM WITH PID = **** IS NØT ØN UMF ØR CARD IS ØUT ØF SEQUENCE.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1717 *** USER FATAL MESSAGE 1717, NUMF TAPE ID HAS ALREADY BEEN SPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1718 *** USER FATAL MESSAGE 1718, NUMF TAPE ID MAY NØT BE RESPECIFIED.

The tape id value for the New User Master File (NUMF) may only be specified once. See Section 2.5 of the User's Manual for details.

1719 *** USER WARNING MESSAGE 17[illegible]UNPRT REQUEST FØR PRØBLEM **** IS ØUT ØF SEQUENCE ØR NØT ØN UMF.

User Master File Editor control cards must form an increasing sequence. See Section 2.5 of the User's Manual for details.

1720 *** SYSTEM FATAL MESSAGE 1720, UMFEDT UNABLE TØ LØCATE BULK DATA ØN NPTP.

1721 *** USER FATAL MESSAGE 1721, BAD USER MASTER FILE EDITØR DATA CARD.

See Section 2.5 of the User's Manual for instructions for using the User Master File Editor.

1722 *** Reserved for future implementation in the User Master File Editor.

1723 *** Reserved for future implementation in the User Master File Editor.

1724 *** Reserved for future implementation in the User Master File Editor.

1725 *** Reserved for future implementation in the User Master File Editor.

1726 *** Reserved for future implementation in the Preface.

1727 *** Reserved for future implementation in the Preface.

1728 *** Reserved for future implementation in the Preface.

1729 *** Reserved for future implementation in the Preface.

1730 *** Reserved for future implementation in the Preface.

1731 *** Reserved for future implementation in the Preface.

1732 *** Reserved for future implementation in the Preface.

1733 *** Reserved for future implementation in the Preface.

1734 *** Reserved for future implementation in the Preface.

1735 *** Reserved for future implementation in the Preface.

1736 *** Reserved for future implementation in the Preface.

1737 *** Reserved for future implementation in the Preface.

1738 *** USER FATAL MESSAGE 1738, UTILITY MØDULE INPUT FIRST PARAMETER VALUE *** ØUT ØF RANGE.

In the test problem generating version of utility module INPUT, the first parameter value specifies the specific problem type as follows:

1. Laplace circuit (an N x N array of scalar points connected by scalar springs and optionally by scalar masses).
2. Rectangular frame made from BARS or RØDS.
3. Rectangular plate made from QUAD1 elements.
4. Rectangular plate made from TRIA1 elements.
5. N-segment string modeled with scalar elements.
6. N-cell beam made from BAR elements.
7. N-order full matrix generator with optional load.
8. N-spoke wheel.

1739 *** SYSTEM FATAL MESSAGE 1739, UNABLE TØ ØPEN FILE ***.

This message can occur if a required output file is purged in utility module INPUT.

1740 *** SYSTEM FATAL MESSAGE 1740, EØF ENCØUNTERED.

An unexpected End-Of-File has been encountered while reading an input data block in utility module INPUT.

1741 *** SYSTEM FATAL MESSAGE 1741, EØR ENCØUNTERED.

An unexpected End-Of-Logical Record indicator has been encountered while reading an input data block in utility module INPUT.

1742 *** SYSTEM FATAL MESSAGE 1742, NØ DATA PRESENT.

Utility module INPUT - input data block contains no data records.

1743 *** SYSTEM FATAL MESSAGE 1743, EØF FRØM FWDREC.

Utility module INPUT encountered an End-Of-File on an input data block while attempting to read past the header record.

1744 *** USER FATAL MESSAGE 1744, DATA CARD(S) ******** GENERATED BY UTILITY MØDULE INPUT NØT ALLØWED IN BULK DATA.

Module is not capable of integrating same card type from two sources.

1745 ************************

Message 1745 is reserved for utility module INPUT.

6.2.3 Functional Module Messages

2001 *** USER FATAL MESSAGE 2001, SEQGP CARD REFERENCES UNDEFINED GRID PØINT ****.

2002 *** SYSTEM FATAL MESSAGE 2002, GRID PØINT **** NØT IN EQEXIN.

This message indicates a program design error in GP1.

2003 *** USER FATAL MESSAGE 2003, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED GRID PØINT ****.

Applies to CØRD1j definitions.

2004 *** USER FATAL MESSAGE 2004, CØØRDINATE SYSTEM **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

Applies to CØRD2j definitions.

2005 *** SYSTEM FATAL MESSAGE 2005, INCØNSISTENT CØØRDINATE SYSTEM DEFINITIØN.

At least one coordinate system cannot be tied to the basic system. See Section 4.21.7 of the Programmer's Manual.

2006 *** USER FATAL MESSAGE 2006, INTERNAL GRID PØINT **** REFERENCES UNDEFINED CØØRDINATE SYSTEM ****.

The grid point whose internal sequence number is printed above references an undefined coordinate system in either field 3 or field 7 of a GRID card.

2007 *** USER FATAL MESSAGE 2007, ELEMENT **** REFERENCES UNDEFINED GRID PØINT ****.

2008 *** USER FATAL MESSAGE 2008, LØAD SET **** REFERENCES UNDEFINED GRID PØINT ****.

2009 *** USER FATAL MESSAGE 2009, TEMP SET **** REFERENCES UNDEFINED GRID PØINT ****.

2010 *** USER FATAL MESSAGE 2010, ELEMENT **** REFERENCES UNDEFINED PRØPERTY ****.

2011 *** USER FATAL MESSAGE 2011, NØ PRØPERTY CARD FØR ELEMENT TYPE ****.

2012 *** USER FATAL MESSAGE 2012, GRID PØINT **** SAME AS SCALAR PØINT.

Identification of grid and scalar points must be unique.

2013 *** USER WARNING MESSAGE 2013, NØ STRUCTURAL ELEMENTS EXIST.

Model checked for structural elements.

2014 *** SYSTEM FATAL MESSAGE 2014, LØGIC ERRØR IN ECPT CØNSTRUCTIØN.

The spill logic in the construction of the skeleton (TA1B) has failed. Problem should be referred to maintenance programming staff. A temporary fix may be available if additional storage can be provided to NASTRAN e.g., by increasing the region size (IBM 360).

2015 *** USER WARNING MESSAGE 2015, EITHER NØ ELEMENTS CØNNECT INTERNAL GRID PØINT ******** ØR IT IS CØNNECTED TØ A RIGID ELEMENT ØR A GENERAL ELEMENT.

The message is a warning only since the degrees of freedom associated with the point may be removed by multipoint constraints or in other ways. The internal identification number is formed by assigning to each grid point and scalar point one of the integers 1,2, --- according to its resequenced position. It may be determined from data block EQEXIN via a DMAP TABPT instruction.

2016 (1) *** USER INFØRMATIØN MESSAGE 2016, GIVENS TIME ESTIMATE IS ******** SECØNDS. PRØBLEM SIZE IS ********, SPILL WILL ØCCUR FØR THIS CØRE AT A PRØBLEM SIZE ØF ******** .

2016 (2) *** USER FATAL MESSAGE 2016, NØ MATERIAL PRØPERTIES EXIST.

2017 *** USER FATAL MESSAGE 2017, MATS1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATS1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2018 *** USER FATAL MESSAGE 2018, MATS2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATS2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2019 *** USER FATAL MESSAGE 2019, MATT1 CARD REFERENCES UNDEFINED MAT1 **** CARD.

The user should check that all MATT1 cards reference MAT1 cards that exist in the Bulk Data Deck.

2020 *** USER FATAL MESSAGE 2020, MATT2 CARD REFERENCES UNDEFINED MAT2 **** CARD.

The user should check that all MATT2 cards reference MAT2 cards that exist in the Bulk Data Deck.

2050 *** USER FATAL MESSAGE 2050, UNDEFINED GRID PØINT **** HAS A SUPPØRT CØØRDINATE.

A SUPØRT card references a grid point which has not been defined.

2051 *** USER FATAL MESSAGE 2051, UNDEFINED GRID PØINT **** IN SINGLE PØINT CØNSTRAINT SET ****.

An SPC1 card in the selected SPC set references a grid point which has not been defined.

2052 *** USER FATAL MESSAGE 2052, UNDEFINED GRID PØINT *** IN SINGLE-PØINT CØNSTRAINT SET ****.

An SPC card in the selected SPC set references a grid point which has not been defined.

2053 *** USER FATAL MESSAGE 2053, UNDEFINED SINGLE-PØINT CØNSTRAINT SET ****.

A single point constraint set selected in the Case Control Deck could not be found on either an SPCADD, SPC or SPC1 card, or a set referenced on an SPCADD card could not be found on either an SPC or SPC1 card.

2054 *** USER FATAL MESSAGE 2054, SUPER ELEMENT **** REFERENCES UNDEFINED SIMPLE ELEMENT ****.

2055 *** SYSTEM WARNING MESSAGE 2055, NØGØ FLAG IS ØN AT ENTRY TØ SMA1A AND IS BEING TURNED ØFF.

2056 *** USER FATAL MESSAGE 2056. UNDEFINED SUPER ELEMENT **** PRØPERTIES.

2057 *** USER FATAL MESSAGE 2057, IRRATIØNAL SUPER ELEMENT **** TØPØLØGY.

2058 *** USER WARNING MESSAGE 2058, ELEMENT ********** CONTRIBUTES TO THE DAMPING MATRIX WHICH IS PURGED. IT WILL BE IGNORED.

2059 *** USER FATAL MESSAGE 2059, UNDEFINED GRID PØINT **** ØN SE--BFE FØR SUPER ELEMENT ****.

2060 *** USER FATAL MESSAGE 2060, UNDEFINED GRID PØINT **** ØN QDSEP CARD FØR SUPER ELEMENT ****.

2061 *** USER FATAL MESSAGE 2061, UNDEFINED GRID PØINT **** ØN GENERAL ELEMENT ****.

2062 *** USER FATAL MESSAGE 6062, UNDEFINED SUPER ELEMENT PRØPERTY **** FØR SUPER ELEMENT ****.

2063 *** SYSTEM FATAL MESSAGE 2063, TA1C LØGIC ERRØR. GENERAL ELEMENT DATA CØULD NØT BE FØUND IN THE ECT DATA BLØCK WHEN TRAILER LIST INDICATED IT WAS PRESENT. REFER PRØBLEM TO MAINTENANCE PRØGRAMMING STAFF.

2064 *** USER FATAL MESSAGE 2064, UNDEFINED EXTRA PØINT **** REFERENCED ØN SEQEP CARD.

2065 *** USER FATAL MESSAGE 2065, UNDEFINED GRID PØINT **** ØN DMIG CARD.

2066 *** USER FATAL MESSAGE 2066, UNDEFINED GRID PØINT **** ØN RLØAD- ØR TLØAD- CARD.

2067 *** USER FATAL MESSAGE 2067, UNDEFINED GRID PØINT ******** IN NØNLINEAR (NØLIN1) LØAD SET ********.

2068 *** USER FATAL MESSAGE 2068, UNDEFINED GRID PØINT **** IN TRANSFER FUNCTIØN SET ****.

2069 *** USER FATAL MESSAGE 2069, UNDEFINED GRID PØINT **** IN TRANSIENT INITIAL CØNDITION SET ****.

2070 *** USER FATAL MESSAGE 2070, REQUESTED DMIG MATRIX **** IS UNDEFINED.

2071 *** USER FATAL MESSAGE 2071, DYNAMIC LØAD SET ******** REFERENCES UNDEFINED ******** SET ********.

This message is issued when DAREA, DELAY, or DPHASE set IDs are referenced on a TLØAD1 or RLØAD1 card but are not defined.

2072 *** SYSTEM WARNING MESSAGE 2072, CARD TYPE *** NØT FØUND ØN DATA BLØCK.

This warning message is issued when the trailer bit for the card type = 1 but the corresponding record is not on the data block.

2073 *** USER INFØRMATIØN MESSAGE 2073, MPYAD METHØD = ****, NØ. ØF PASSES = ****.

This message gives the method selected and number of passes required.

2074 *** USER FATAL MESSAGE 2074, UNDEFINED TRANSFER FUNCTIØN SET ****.

2075 *** SYSTEM ØR USER DMAP FATAL MESSAGE 2075, IMPRØPER VALUE **** FØR FIRST PARAMETER IN DMAP INSTRUCTIØN SDR2.

2076 *** USER WARNING MESSAGE 2076, SDR2 ØUTPUT DATA BLØCK NØ. 1 IS PURGED.

2077 *** USER WARNING MESSAGE 2077, SDR2 ØUTPUT DATA BLØCK NØ. 2 IS PURGED.

2078 *** USER WARNING MESSAGE 2078, SDR2 ØUTPUT DATA BLØCK NØ. 3 IS PURGED.

2079 *** USER WARNING MESSAGE 2079, SDR2 FINDS THE -EDT-, -EST-, ØR -GPTT- PURGED ØR INADEQUATE AND IS THUS NØT PRØCESSING ANY REQUESTS FØR STRESSES ØR FØRCES.

2080 *** USER WARNING MESSAGE 2080, SDR2 ØUTPUT DATA BLØCK NØ. 6 IS PURGED.

2081 *** USER FATAL MESSAGE 2081, NULL DIFFERENTIAL STIFFNESS MATRIX.

Differential stiffness is not defined for all structural elements. Only the following elements are defined for differential stiffness calculations: RØD, TUBE, SHEAR (but not TWIST) panels, triangular and quadrilateral membranes (TRMEM, TRIA2, QDMEM, QUAD2), and BAR. The combination two dimensional elements TRIA1 and QUAD1, are defined only if their membrane thickness is nonzero. The user has not included any of these elements in his model and therefore a null differential stiffness matrix was generated.

2083 *** USER FATAL MESSAGE 2083, NULL DISPLACEMENT VECTØR.

The displacement vector for the linear solution part of a static analysis with differential stiffness problem, or the incremental displacement vector in a piecewise linear analysis rigid format problem is the zero vector. Check loading conditions.

2084 *** SYSTEM FATAL MESSAGE 2084, DSMG2 LØGIC ERRØR ****.

Incompatible input and output pairs in the DMAP calling sequence to module DSMG2. See the module description for DSMG2 in the Programmer's Manual.

2085 *** USER INFØRMATIØN MESSAGE 2085, **** SPILL, NPVT ****.

During processing of the ECPT data block in module ****, so many elements were attached to the referenced pivot point (NPVT) that module spill logic was initiated.

2086 *** USER INFØRMATIØN MESSAGE 2086, SMA2 SPILL, NPVT ****.

See explanation for Message 2085.

2087 *** SYSTEM FATAL MESSAGE 2087, ECPT CØNTAINS BAD DATA.

Use the TABPT module to print the ECPT data block.

2160 *** USER FATAL MESSAGE 2160, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ********************.

2161 *** SYSTEM WARNING MESSAGE 2161, PARTITIØN FILE, **** IS ØF SIZE ********** RØWS BY ********** CØLS. PARTITIØNING VECTØRS INDICATE THAT THIS PARTITIØN SHØULD BE ØF SIZE ********** RØWS BY ********** CØLUMNS FØR A SUCCESSFUL MERGE.

2162 *** SYSTEM WARNING MESSAGE 2162, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE IS INCØNSISTENT WITH THE SIZE ØF THE MERGED MATRIX, HØWEVER IT HAS BEEN USED. FØRM = **********, SIZE = ********** RØWS BY ********** CØLUMNS.

2163 *** SYSTEM WARNING MESSAGE 2163, THE FØRM PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET, ØR IS ØF ILLEGAL VALUE. THE FØRM ØF THE MERGED MATRIX HAS BEEN SET = **********.

2164 *** SYSTEM WARNING MESSAGE 2164, THE TYPE PARAMETER AS GIVEN TØ THE MERGE MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE MERGED MATRIX HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2165 *** USER FATAL MESSAGE 2165, ILLEGAL GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER ********************.

2166 *** SYSTEM WARNING MESSAGE 2166, MATRIX TØ BE PARTITIØNED IS ØF SIZE ********** RØWS BY ********** CØLUMNS. RØW PARTITIØN SIZE IS ********** CØLUMN PARTITIØN SIZE IS ********** (INCØMPATIBLE).

2167 *** SYSTEM WARNING MESSAGE 2167, THE TYPE PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. THE TYPE ØF THE PARTITIØNS HAS BEEN SET TØ REAL-SINGLE-PRECISIØN.

2168 *** SYSTEM WARNING MESSAGE 2168, THE FØRM PARAMETER AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** IS INCØNSISTENT WITH ITS SIZE. FØRM = **********, SIZE = ********** ROWS BY ********** CØLUMNS.

2169 *** SYSTEM WARNING MESSAGE 2169, THE FØRM PARAMETERS AS GIVEN TØ THE PARTITIØNING MØDULE FØR SUB-PARTITIØN ******** HAS NØT BEEN SET ØR IS ØF ILLEGAL VALUE. IT HAS BEEN RESET = **********.

2170 *** SYSTEM FATAL MESSAGE 2170, BØTH THE RØW AND CØLUMN PARTITIØNING VECTØRS ARE PURGED AND ØNLY ØNE MAY BE.

2171 *** SYSTEM WARNING MESSAGE 2171, SYM FLAG INDICATES TØ THE PARTITIØN ØR MERGE MØDULE THAT A SYMMETRIC MATRIX IS TØ BE ØUTPUT. THE PARTITIØNING VECTØRS ******** HØWEVER DØ NØT CØNTAIN AN IDENTICAL NUMBER ØF ZERØS AND NØN-ZERØS.

2172 *** SYSTEM WARNING MESSAGE 2172, RØW AND CØLUMN PARTITIØNING VECTØRS DØ NØT HAVE IDENTICAL ØRDERING ØF ZERØ AND NØN-ZERØ ELEMENTS, AND SYM FLAG INDICATES THAT A SYMMETRIC PARTITIØN ØR MERGE IS TØ BE PERFØRMED.

2173 *** SYSTEM WARNING MESSAGE 2173, PARTITIØNING VECTØR FILE **** CØNTAINS ********** CØLUMNS. ØNLY THE FIRST CØLUMN IS BEING USED.

2174 *** SYSTEM WARNING MESSAGE 2174, PARTITIØNING VECTØR ØN FILE **** IS NØT REAL-SINGLE ØR REAL-DØUBLE PRECISIØN.

2175 *** SYSTEM FATAL MESSAGE 2175, THE RØW PØSITIØN ØF AN ELEMENT ØF A CØLUMN ØN FILE **** IS GREATER THAN NUMBER ØF RØWS SPECIFIED BY TRAILER.

2176 *** SYSTEM FATAL MESSAGE 2176, FILE **** EXISTS BUT IS EMPTY.

2177 *** USER INFØRMATIØN MESSAGE 2177, SPILL WILL ØCCUR IN SYMMETRIC CØMPLEX DECØMPØSITIØN.

2178 *** SYSTEM FATAL MESSAGE 2178, GINØ REFERENCE NAMES, IMPRØPER FØR SUBRØUTINE FILSWI.

2179 *** SYSTEM FATAL MESSAGE 2179, ERRØR DETECTED IN FUNCTIØN FØRFIL ****, **** NØT IN FIST.

2180 *** USER WARNING MESSAGE 2180, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2181 *** SYSTEM FATAL MESSAGE 2181, SCDCMP CALLED TØ SØLVE A 1X1 ØR 2X2 MATRIX.

2182 *** USER WARNING MESSAGE 2182, SUBRØUTINE ******** IS DUMMY. ØNLY ØNE ØF THESE MESSAGES WILL APPEAR PER ØVERLAY ØF THIS DECK.

2183 *** USER WARNING MESSAGE 2183, SYMMETRIC DECØMPØSITIØN ØF A MATRIX WHØSE FØRM IS SQUARE (BUT NØT SYMMETRIC) WILL BE ATTEMPTED.

2184 *** SYSTEM WARNING MESSAGE 2184, STRESS ØR FØRCE REQUESTS FØR ELEMENT TYPE = **************** WILL NØT BE HØNØRED AS THIS ELEMENT IS NØT A STRUCTURAL ELEMENT.

Stress and force requests for fluid, mass, damping, plotel, and heat boundary elements are automatically ignored.

2187 *** USER FATAL MESSAGE 2187, INSUFFICIENT WØRKING CØRE TØ HØLD FØRTRAN LØGICAL RECØRD.
LENGTH ØF WØRKING CØRE = **********.
LENGTH ØF FØRTRAN LØGICAL RECØRD = **********.

2188 *** USER INFØRMATION MESSAGE 2188, UNUSED CØRE = ********** WØRDS.

2189 *** USER INFØRMATION MESSAGE 2189, ADDITIØNAL CØRE REQUIRED TØ AVØID SPILL = ********** (DECIMAL) WØRKS.

2190 *** SYSTEM FATAL MESSAGE 2190, ILLEGAL VALUE FOR KEY = **********. EXPECTED VALUE = **********.

2191 *** USER WARNING MESSAGE 2191, ELEMENT TYPE ********** IS PRESENT AND IS BEING IGNØRED BY SMA1 SINCE ØPTION PARAM = ********.

2192 *** USER FATAL MESSAGE 2192, UNDEFINED GRID PØINT ******** IN RIGD* ELEMENT ********.

2193 *** USER FATAL MESSAGE 2193, A REDUNDANT SET ØF RIGID BØDY MØDES WAS SPECIFIED FØR THE GENERAL ELEMENT.

Only a non-redundant list of rigid body modes is allowed to appear in the u_d set when the S matrix is to be internally calculated in subroutine TA1CA.

2194 *** USER FATAL MESSAGE 2194, A MATRIX D IS SINGULAR IN SUBRØUTINE TA1CA.

While attempting to calculate the [S] matrix for a general element in TA1CA, it was discovered that the matrix D_d which relates $\{u_b\}$ to $\{u_d\}$ was singular and could not be inverted.

2195 *** USER WARNING MESSAGE 2195, ILLEGAL VALUE FØR P4 = ******.

2196 *** USER WARNING MESSAGE 2196, DUMMY SUBRØUTINE TIMTS3.
DUMMY SUBRØUTINE TIMTS4.
DUMMY SUBRØUTINE TIMTS5.

2197 *** SYSTEM FATAL MESSAGE 2197, ABØRT CALLED DURING TIME TEST ØF *********.

2198 *** SYSTEM FATAL MESSAGE 2198, INPUT DATA BLØCK, ******** HAS BEEN PURGED.

2199 *** SYSTEM FATAL MESSAGE 2199, SUMMARY/ ØNE ØR MØRE ØF THE ABØVE FATAL ERRØRS WAS ENCØUNTERED IN SUBRØUTINE ********.

2200 *** USER FATAL MESSAGE 2200. INCØNSISTENT RIGID BØDY SYSTEM.

2201 *** USER FATAL MESSAGE 2201. REQUIRED DATA BLØCK FØR GINØ FILE, ***, IS PURGED IN SUBRØUTINE ********.

2202 *** USER FATAL MESSAGE 2202. PARAMETER, ***, HAS ILLEGAL VALUE ØF ********.

2203 *** USER FATAL MESSAGE 2203. PARAMETER, ***, FOR SUBSTRUCTURE ID ******** INDICATES IT IS AN IDENTICAL SUBSTRUCTURE BUT INPUT DATA BLØCK ØF PREVIØUS SUBSTRUCTURE IS PURGED.

2204 *** USER FATAL MESSAGE 2204. PARAMETER, ***, HAS A VALUE ØF ********, BUT CØRRESPØNDING INPUT DATA BLØCK, ***, IS NØN-PURGED.

2205 *** USER WARNING MESSAGE 2205. *** SUBSTRUCTURE HAVE BEEN SPECIFIED. NØ WØRK CAN BE DØNE FØR THIS CASE.

2206 *** USER FATAL MESSAGE 2206. PARAMETERS ** AND ** HAVE THE SAME SUBSTRUCTURE ID VALUES.

2207 *** USER FATAL MESSAGE 2207. NØ SAME DATA SUPPLIED ØR GENERATED FØR PVEC RUN - EXECUTION TERMINATED.

2208 *** USER FATAL MESSAGE 2208, END ØF FILE ENCØUNTERED ØN GINØ FILE, ***, IN SUBRØUTINE ********.

2209 *** USER FATAL MESSAGE 2209, END ØF RECØRD ENCØUNTERED ØN GINØ FILE, ***, IN SUBRØUTINE ******.

2211 *** USER FATAL MESSAGE 2211, LØGIC ERRØR IN ********.

2213 *** USER FATAL MESSAGE 2213, ILLEGAL SAME DATA. PSEUDØSTRUCTURE CØNTAINS INCØRRECTLY CØUPLED SUBSTRUCTURES.

2251 *** USER WARNING MESSAGE 2251, PHYSICALLY UNREALISTIC VALUE FØR NU ØN MAT1 CARD ********. VALUE = ****************.

2252 *** USER FATAL MESSAGE 2252, GINØ FILE, ***, IS PURGED.

2253 *** USER FATAL MESSAGE 2253, ILLEGAL VALUE FØR ØNE ØR MØRE INPUT PARAMETERS - ********** ********** **********).

2254 *** USER FATAL MESSAGE 2254. END-ØF-FILE ØN GINØ FILE ***.

2255 *** USER FATAL MESSAGE 2255, GINØ FILE 102 HAS CØNTRØL RECORD ØF LENGTH, ***** / EXPECTED LENGTH ØF CØNTRØL RECØRD IS *****.

2256 *** USER FATAL MESSAGE 2256, NØN-UNIQUE FIRST GRØUP ENTRY. THE TWØ GRØUPS FØLLØW.

2257 *** USER WARNING MESSAGE 2257, SET *** REFERENCED ØN SPLINE CARD **** IS EMPTY.

While processing the SET1 or SET2 card referenced on the SPLINEi card, no included grid points were found. If SET1 was used, either no points were included or they were all scalar points. If SET2 was used, the volume of space referenced did not include any structural grid points. This may occur if a tapered element is extended too far. The spline is omitted from the problem and processing continues.

2258 *** USER FATAL MESSAGE 2258, SET **** REFERENCED ØN SPLINE CARD **** NØT FØUND ØR IT IS EMPTY.

The necessary SET1 or SET2 card was not found or was empty. Include the proper set card or, if it is already included, make sure that the set is not empty. (See description under User Warning Message 2257 shown above).

2259 *** SYSTEM FATAL MESSAGE 2259, PØINT ASSIGNED TØ BØX **** FØR CAERØ* **** NØT IN EQAERØ.

No internal k point could be found for external box. If box number is okay, module APD is in error; if box number is bad, module GI is in error.

2260 *** USER FATAL MESSAGE 2260, SINGULAR MATRIX DEVELØPED WHILE PRØCESSING SPLINE ****

Matrix developed by SSPLIN or LSPLIN (depending on type of spline) could not be inverted; possibly for the Surface Spline all points lie in a straight line, or not enough points are included.

2261 *** USER FATAL MESSAGE 2261, PLANE ØF LINEAR SPLINE **** PERPENDICULAR TØ PLANE ØF AERØ ELEMENT ****

Y-axis of linear spline was perpendicular to connected element and could not be projected onto element.

2262 *** USER FATAL MESSAGE 2262, SPLINE **** INCLUDES AERØ BØX INCLUDED ØN AN EARLIER SPLINE.

Two splines are attached to the same box. Splines may be connected to the same structural grid point but not the same aerodynamic grid point. This type of error checking will stop with one error, so check this spline and subsequent splines (sorted) for overlaps before resubmitting.

2263 *** USER FATAL MESSAGE 2263, INSUFFICIENT CØRE TØ PRØCESS SPLINE ****

Depending on type of spline and input options, subroutine SSPLIN, or LSPLIN would not have had enough core for this spline. Either allow more core or break this spline into smaller splines.

2264 *** SYSTEM FATAL MESSAGE 2264, NUMBER ØF RØWS CØMPUTED (****) WAS GREATER THAN SIZE REQUESTED FØR ØUTPUT MATRIX (****)

Module ADD determines size of output matrices (j set size). Sum of number of rows added by different method total more than maximum allowed.

2265 *** USER FATAL MESSAGE 2265, METHØD **** FØR AERØELASTIC MATRIX GENERATIØN IS NØT IMPLEMENTED.

A nonimplemented method for computing these matrices was input.

2266 *** USER FATAL MESSAGE 2266, ØNE ØR MØRE ØF THE FØLLØWING FLFACT SETS WERE NØT FØUND *** ***

One or more of the FLFACT ID's on the flutter data card could not be found. Include all sets mentioned.

2267 *** USER FATAL MESSAGE 2267, INTERPØLATIØN METHØD **** UNKNØWN.

Matrix interpolation method on FLUTTER card is not implemented.

2268 *** USER FATAL MESSAGE 2268, FMETHØD SET **** NØT FØUND.

FLUTTER data card for FMETHØD = **** in case control could not be found.

2269 *** USER FATAL MESSAGE 2269, FLUTTER METHØD **** NØT IMPLEMENTED.

Flutter analysis method on FLUTTER data card is not implemented.

2269A *** USER FATAL MESSAGE 2269A, FLUTTER METHØD **** NØT IMPLEMENTED WITH B MATRIX.

The KE method cannot be requested when structural damping is included.

2270 *** USER FATAL MESSAGE 2270, LINEAR INTERPØLATIØN WITHØUT ENØUGH INDEPENDENT MACH NUMBERS EQUAL TØ DEPENDENT MACH ****.

Linear interpolation is for points with the same Mach number, and less than two more found from the QHHL list which matched the requested Mach on an FLFACT list.

2271 *** USER FATAL MESSAGE 2271, INTERPØLATIØN MATRIX IS SINGULAR.

Possibly for the surface spline, all the Mach numbers were the same, or for either method, not enough points were included.

2272 *** USER INFØRMATIØN MESSAGE 2272, NØ FLUTTER CALCULATIØNS CAN BE MADE IN MØDULE ADR SINCE BØV = 0.0.

2273 *** USER FATAL MESSAGE 2273, CAERØ2 ******** NØT INPUT IN Z, ZY, Z SEQUENCE.

The EID for z-bodies, zy-bodies, and y-bodies must be ordered in an increasing sequence following the EID of a panel on a CAERØ1 card.

2274 *** USER FATAL MESSAGE 2274, ASSØCIATED BØDY ******** WAS NØT FØUND WITH CAERØ2 GRØUP ********.

Aerodynamic bodies must be assigned to an interference group.

2275 *** USER FATAL MESSAGE 2275, CAERØ2 ******** HAS INCØNSISTANT USE FØR THI ØR THN, ØR LTH2 IS REQUIRED.

A conflict exists between the data on a CAERØ2 card and a PAERØ2 card.

2276 *** USER FATAL MESSAGE 2276, THI1 AND THN1 REQUIRED FØR CAERØ2 ********.

Required data on a PAERØ2 card not found for the referenced CAERØ2 card.

2277 *** USER FATAL MESSAGE 2277, CAERØ2 BØDY ********* DØES NØT HAVE ENØUGH SLENDER ELEMENTS.

At least two slender body elements are required.

2278 *** USER FATAL MESSAGE 2278, PLANFØRM GEØMETRY FØR CAERØ3 ID ******** IS IN ERRØR, CHECK SWEEP ANGLE FØR LEADING EDGE ØR CØNTROL SURFACE HINGE LINE.

2279 *** SYSTEM INFØRMATIØN MESSAGE 2279, **** ITERATIØNS ØN LØØP, **** FØUND, **** RØØTS WANTED, **** THIS LØØP STØPPED.

2288 *** SYSTEM FATAL MESSAGE 2288. **** READ INCØRRECT NUMBER WØRDS (**** ****).

Subroutine **** read **** words on the **** card which is incorrect.

2289 *** USER FATAL MESSAGE 2289. **** INSUFFICIENT CØRE (****). **** = MATERIAL, **** = PØINTERS, **** = ELEMENTS, **** = PRØPERTIES.

Module ØPTPR1 or ØPTPR2 gives the open core available and the pointers to the start of each contiguous section of core.

2290 *** USER FATAL MESSAGE 2290. THE FØLLØWING ILLEGAL ELEMENT TYPES FØUND ØN PLIMIT CARD.

This message is followed by a list of element types. Processing of legal element types continues so as to discover other errors.

2291 *** USER FATAL MESSAGE 2291, PLIMIT RANGE INCØRRECT FØR **** THRU **** AND **** THRU ****.

Property identification numbers are repeated. The first pair is rejected and processing of the remaining ranges continues to discover other errors.

2292 *** USER FATAL MESSAGE 2292. INSUFFICIENT CØRE FØR PLIMIT DATA, ELEMENT ****, **** WØRDS SKIPPED.

The element type **** being processed exceeded core by **** words. Processing of other element types continues to discover additional requirements.

2293 *** USER FATAL MESSAGE 2293. NØ PID ENTRIES ØN PLIMIT CARD (****).

A PLIMIT card of element type **** had no property entries.

2294 *** USER FATAL MESSAGE 2294. DUPLICATE **** THRU **** RANGE FØR ELEMENT **** REJECTED PLIMIT. SCAN CØNTINUED.

Property identification numbers are repeated for element type ****.

2295 *** USER FATAL MESSAGE 2295. NØ ELEMENTS EXIST FØR ØPTIMIZATIØN.

A non-null property card and its corresponding material stress limit is needed. In subroutine ØPT2A stress data is also required.

2296 *** USER FATAL MESSAGE 2296. INSUFFICIENT CØRE **** (****), ELEMENT ****.

Subroutine **** has insufficient core when loading element type or number ****. Elements are read into core by element type (see /GPTA1/ sequence) then by sequential element number.

2297 *** SYSTEM FATAL MESSAGE 2297. INCØRRECT LØGIC FØR ELEMENT TYPE ****, ELEMENT ****, (****).

Subroutine (****) has sequential element search. Element type can be found in /GPTA1/.

2298 *** USER FATAL MESSAGE 2298. INSUFFICIENT CØRE **** (****), PROPERTY ****.

Subroutine **** (core ****) had insufficient core when loading property ****.

2299 *** SYSTEM FATAL MESSAGE 2299. INCØRRECT LØGIC FØR ELEMENT TYPE ***, PRØPERTY **** (****).

Subroutine ØPTP1B has sequential property search. A property card had two entries per card and it was unsorted.

2300 *** SYSTEM FATAL MESSAGE 2300, **** UNABLE TØ LØCATE PRØPERTY **** ØN EPT ØR IN CØRE.

2301 *** SYSTEM FATAL MESSAGE 2301, ØPTP1D FILE ØPTIMIZATIØN PARAMETER INCØRRECT AS **** ****.

Check subroutines ØPTPX and ØPTP1D use of the scratch file. In ØPTPR2, the corresponding stress limit(s) is zero.

2302 *** USER FATAL MESSAGE 2302, SUBRØUTINE **** HAS NØ PRØPERTY ØR ELEMENT DATA.

2303 *** USER INFØRMATIØN MESSAGE 2303. ØPTPR2 DETECTED ZERØ ALPHA FØR PRØPERTY ****.

The stress in the element was zero. Only 100 message per iteration may occur.

2304 *** USER INFØRMATIØN MESSAGE 2304, ØPTP2B CØNVERGENCE ACHIEVED, HIGHEST VALUE IS ****.

2305 *** USER INFØRMATIØN MESSAGE 2305, ØPTPR2 DETECTED NEGATIVE ALPHA FØR ELEMENT ****.

The element did not have stress data or appropriate material stress limits. The element properties were not changed. Only 100 of these messages will occur per print iteration.

2314 *** USER INFØRMATIØN MESSAGE 2314, STATISTICS FØR SYMMETRIC DECØMPØSITIØNS ØF DATA BLØCK, **** ****, FØLLØW / NUMBER ØF UII .LT. 0 = ***** / MAXIMUM ABSØLUTE VALUE ØF AII/UII = ***** / N1 THRU N6 = ****** ****** ****** ****** ****** ****** / RØW NUMBERS ØF 5 LARGEST AII/UII = ****** ****** ****** ****** ******.

This message will appear if the NASTRAN card SYSTEM(57)=1 is placed before the ID card. See Programmer's Manual Section 3.5.14 for a discussion of the statistics appearing in the message.

2316 *** USER INFØRMATIØN MESSAGE 2316, INSUFFICIENT CØRE, TØ PREPARE DECØMPØSITIØN STATISTICS.

2317 *** USER WARNING MESSAGE 2317, PARAM HAS STØRED ØUTSIDE DEFINED RANGE ØF CØMMØN BLØCK /SYSTEM/. INDEX VALUE = ********************.

2318 *** USER FATAL MESSAGE 2318, NØ AERØ CARD FØUND.

An AERØ card is required to run APD.

2319 *** USER FATAL MESSAGE 2319, NØ CAERØ* CARDS FØUND.

At least one CAERØi card is required for APD.

2320 *** USER FATAL MESSAGE 2320, NØ AEFACT CARDS FØUND.

An AEF... has been referenced and none have been found in the input.

2321 *** USER FATAL MESSAGE 2321, NØ FLUTTER CARDS FØUND.

Flutter analysis requires at least one FLUTTER card.

2322 *** USER FATAL MESSAGE 2322, NEITHER MKAERØ1 ØR MKAERØ2 CARDS FØUND.

Either MKAERØ1 or MKAERØ2 cards are required.

2323 *** USER FATAL MESSAGE 2323, PAERØ* CARD NØ. ******** REFERENCED BY CAERØ* CARD NØ. ******** BUT DØES NØT EXIST.

CAERØi card points to missing PAERØi card.

2324 *** USER FATAL MESSAGE 2324, CAERØ* ELEMENT NØ. ******** REFERENCED ØN A SPLINE* CARD DØES NØT EXIST.

Either a SPLINE1, a SPLINE2, or a SPLINE3 card references a CAERØi card which is missing.

2325 *** USER FATAL MESSAGE 2325, CAERØ* ELEMENT NØ. ******** REFERENCED ØN A SET2 CARD DØES NØT EXIST.

A SET2 card points to a CAERØi which was not included.

2326 *** USER FATAL MESSAGE 2326, CAERØ* ELEMENT NØ. ******** REFERENCES AEFACT CARD NØ. ******** WHICH DØES NØT EXIST.

The listed CAERØi card requires one AEFACT card for LSPAN.

2327 *** USER FATAL MESSAGE 2327, CAERØ* ELEMENT NØ. ******** REFERENCES AEFACT CARD NØ. ******** WHICH DØES NØT EXIST.

The listed CAERØi card requires one AEFACT card for LCHØRD.

2328 *** USER FATAL MESSAGE 2328, SET* AND SPLINE* CARDS REQUIRED.

At least one SET1 or SET2 card and at least one SPLINE1, SPLINE2, or SPLINE3 care required.

2329 *** USER FATAL MESSAGE 2329, DUPLICATE EXTERNAL ID NØ. ******** GENERATED.

The external IDs assigned to each generated box must be unique.

2330 *** USER FATAL MESSAGE 2330, SET1 ØR SPLINE3 CARD NØ. ******** REFERENCES EXTERNAL ID NØ. ******** WHICH DØES NØT EXIST.

External grid point IDs referenced on a SET1 or SPLINE3 card do not exist as structural grid points.

2331 *** USER FATAL MESSAGE 2331, BØX PICKED ØN SPLINE CARD NØ. ******** NØT GENERATED BY CAERØ CARD NØ. ********.

SPLINE card ******** points to a box which was not generated by the CAERØi card.

2332 *** USER WARNING MESSAGE 2332, INVALID INPUT DATA DETECTED IN DATA BLØCK, [illegible] PRØCESSING STØPPED FØR THIS DATA BLØCK.

2333 *** SYSTEM INFØRMATIØN MESSAGE 2333, MØDULE DDRMM TERMINATED WITH VARIABLE IERRØR = **********.

2334 *** SYSTEM WARNING MESSAGE 2334, ILLEGAL MAJØR ØR MINØR ØFP-ID IDENTIFICATIØNS = ********* ********** DETECTED IN DATA BLØCK, ****, PRØCESSING ØF SAID DATA BLØCK DISCØNTINUED.

2335 *** SYSTEM WARNING MESSAGE 2335, THE AMØUNT ØF DATA IS NØT CØNSISTENT FØR EACH EIGENVALUE IN DATA BLØCK **** PRØCESSING ØF THIS DATA BLØCK TERMINATED.

2336 *** SYSTEM WARNING MESSAGE 2336, A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK **** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2337 *** USER WARNING MESSAGE 2337, DATA BLØCK **** CAN NØT BE PRØCESSED DUE TØ A CØRE INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2338 *** USER WARNING MESSAGE 2338, DATA BLØCK **** MAY NØT BE FULLY CØMPLETED DUE TØ A CØRE INSUFFICIENCY ØF APPRØXIMATELY ********** DECIMAL WØRDS.

2339 *** SYSTEM WARNING MESSAGE 2339, A CHANGE IN WØRD 2 ØF THE ØFP-ID RECØRDS ØF DATA BLØCK **** HAS BEEN DETECTED. PRØCESSING ØF THIS DATA BLØCK HAS BEEN TERMINATED.

2340 *** USER WARNING MESSAGE 2340, MØDULE **** ****, HAS BEEN REQUESTED TØ DØ UNSYMMETRIC DECØMPØSITIØN ØF A SYMMETRIC MATRIX.

2341 *** USER WARNING MESSAGE 2341, MØDULE **** **** HAS BEEN FURNISHED A SQUARE MATRIX MARKED UNSYMMETRIC FØR SYMMETRIC DECØMPØSITIØN.

2342 *** USER WARNING MESSAGE 2342, UNRECØGNIZED DMAP APPRØACH PARAMETER = **** ****.

2343 *** SYSTEM WARNING MESSAGE 2343, DATA BLØCK, *****, IS EITHER NØT -EQEXIN- ØR PØSSIBLY INCØRRECT.

2344 *** SYSTEM WARNING MESSAGE 2344, GPFDR FINDS ELEMENT = **** ****, HAS AN ECT ENTRY LENGTH TØØ LONG FØR A PRØGRAM LØCAL ARRAY.

2345 *** SYSTEM WARNING MESSAGE 2345, GPFDR FINDS AND IS IGNØRING UNDEFINED ECT DATA WITH LØCATE NUMBERS = ******** ******** ********.

2346 *** SYSTEM WARNING MESSAGE 2346, GPFDR FINDS DATA FØR EL-TYPE = **********, IN DATA BLØCK, ********** NØT TØ BE IN AGREEMENT WITH THAT WHICH IS EXPECTED.

2347 *** USER WARNING MESSAGE 2347, GPFDR FINDS TØØ MANY ACTIVE CØNNECTING GRID PØINTS FØR ELEMENT ID = **********.

2348 *** SYSTEM WARNING MESSAGE 2348, GPFDR DØES NØT UNDERSTAND THE MATRIX-DICTIØNARY ENTRY FØR ELEMENT ID = **********.

2349 *** SYSTEM WARNING MESSAGE 2349. GPFDR FINDS AN ELEMENT ENTRY CØNNECTING PIVØT SIL = **********, ØN DATA BLØCK ***** TØØ LARGE FØR A LØCAL ARRAY. ENTRY IS BEING IGNØRED.

2350 *** SYSTEM WARNING MESSAGE 2350, GPFDR CANNØT FIND PIVØT SIL = **********, AMØNG THE SILS ØF ELEMENT ID = ********** AS READ FRØM DATA BLØCK, *****, ENTRY THUS IGNØRED.

2351 *** USER INFØRMATIØN MESSAGE 2351, A FØRCE CØNTRIBUTIØN DUE TØ ELEMENT TYPE = **** ****, ØN PØINT ID = **********, WILL NØT APPEAR IN THE GRID-PØINT-FØRCE-BALANCE SUMMARY.

2352 *** SYSTEM WARNING MESSAGE 2352, GPFDR IS NØT ABLE TØ FIND PIVØT SIL = ********** AS READ FRØM DATA BLØCK ***** IN TABLE ØF SILS.

2353 *** USER WARNING MESSAGE 2353. INSUFFICIENT CØRE TØ HØLD ALL NØN-ZERØ APP-LØAD AND F-ØF-SPC ØUTPUT LINE ENTRIES ØF GRID-PØINT-FØRCE-BALANCE REQUESTS. SØME PØINTS REQUESTED FØR ØUTPUT WILL BE MISSING THEIR APP-LØAD ØR F-ØF-SPC CØNTRIBUTIØN IN THE PRINTED BALANCE.

2354 *** SYSTEM WARNING MESSAGE 2354, GPFDR MØDULE IS UNABLE TØ CØNTINUE AND HAS BEEN TERMINATED DUE TØ ERRØR MESSAGE PRINTED ABØVE ØR BELØW THIS MESSAGE. THIS ERRØR ØCCURRED IN GPFDR CØDE WHERE THE VARIABLE -NERRØR- WAS SET = *****.

2355 *** USER FATAL MESSAGE 2355, GRID PØINT CØØRDINATES ØF ELEMENT ******** ARE IN ERRØR. ØNE ØR MØRE ØF THE R-CØØRDINATES ARE ZERØ ØR NEGATIVE.

2357 *** USER WARNING MESSAGE 2357, ØNE VECTØR (DEFAULT) WILL BE CØMPUTED IN THE CØMPLEX REGIØN.

If more than one vector is desired from the Hessenburg method, make a specific request on the EIGC card.

2358 *** USER WARNING MESSAGE 2358, SYMMETRIC SCRIPT-AF MATRIX (HREE) ASSUMED IN RADMTX.

2359 *** USER WARNING MESSAGE 2359, CØL *****, RØW ***** ØF RADMTX IS NEGATIVE.

2360 *** USER FATAL MESSAGE 2360, TØTAL VIEW FACTØR (FA/A), FØR ELEMENT ******** IS ***************(ELEMENT AREA IS ***************).

Provides view factors and areas for all elements with a view factor greater than 1.01. This message is also a WARNING for all elements with a view factor between .99 and 1.01 provided the NASTRAN card, SYSTEM(58)=1, is included in the deck.

2361 *** USER INFØRMATION MESSAGE 2361, **** ELEMENTS HAVE A TØTAL VIEW FACTØR (FA/A) LESS THAN 0.99, ENERGY MAY BE LØST TØ SPACE.

Provides the total number of elements with a view factor less than .99.

2362 *** USER FATAL MESSAGE 2362, CHBDY CARDS WITH DUPLICATE IDS FØUND IN EST, CHBDY ID NUMBER = **********.

2363 *** SYSTEM WARNING MESSAGE 2363, SSG2B FØRCED MPYAD CØMPATIBILITY ØF MATRIX ØN ***** FRØM (*****, *****) TØ (*****, *****).

This message identifies a matrix and its initial size (row, column) and its changed size (row, column) so that it is compatible with MPYAD operations.

2364 *** USER FATAL MESSAGE 2364, GRID PØINT CØØRDINATES ØF ELEMENT ******** ARE IN ERRØR. ØNE ØR MØRE ØF THE THETA-CØØRDINATES ARE NØNZERØ.

2365 *** USER WARNING MESSAGE 2365, INSUFFICIENT CØRE FØR HESSENBURG METHØD. SWITCHING TØ INVERSE PØWER.

2366 *** USER FATAL MESSAGE 2366, REGIØN IMPRØPERLY DEFINED ØN EIGC CARD.

If insufficient core has caused an automatic switch from Hessenburg method to Inverse Power method, the EIGC card must have the region(s) defined (they are ignored for the Hessenburg method). Either increase core to use the Hessenburg method or define the region(s) for Inverse Power.

2367 *** USER WARNING MESSAGE 2367, FREQUENCY F1 (FIELD 4) ØN THE EIGR BULK DATA CARD IS NEGATIVE. IT IS ASSUMED TØ BE ZERØ FØR CALCULATIØN PURPØSES.

2369 *** USER WARNING MESSAGE 2369, WHEEL MUST HAVE FEWER THAN 256 SPØKES. INPUT MØDULE RESETTING TØ 255.

See Section 2.6 for a discussion of INPUT module sample 8.

2370 *** USER WARNING MESSAGE 2370, MULTIPØINT CØNSTRAINT FØRCES NØT CALCULATED IN ****** DUE TØ MISSING INPUT FILE.

2371 *** USER WARNING MESSAGE 2371, EQUILIBRIUM FØRCES NØT CALCULATED IN ****** DUE TØ MISSING INPUT FILE.

2372 *** USER WARNING MESSAGE 2372, ****** IS UNABLE TØ CALCULATE RIGID BØDY TRANSFØRMATIØN FØR SCALAR MØDEL.

2373 *** USER WARNING MESSAGE 2373, ØNLY SØRT1-REAL SUPPØRTED IN ********.

2374 *** USER WARNING MESSAGE 2374, INSUFFICIENT CØRE TØ PRØCESS MØRE THAN **** VECTØRS IN ****.

Output module EQMCK needs 6 words for loads, MPCs and SPCs for each subcase or eigenvalue plus 2 (statics) or 3 (eigenvalue) buffers.

2375 *** SYSTEM WARNING MESSAGE 2375, MØDULE ******** HAS BEEN REQUESTED TØ DECØMPØSE A RECTANGULAR MATRIX.

Symmetric decomposition will not accept rectangular matrix input.

2376 *** USER WARNING MESSAGE 2376, INSUFFICIENT CØRE IN **** HAS ****, NEEDS ****.

2377 (A) *** USER WARNING MESSAGE 2377A, MATRIX CØNDITIØNING ERRØRS GIVEN WITH EXTERNAL ID.

2377 (B) *** USER WARNING MESSAGE 2377B, MATRIX CØNDITIØNING ERRØRS GIVEN WITH INTERNAL ID.

Symmetric decomposition diagnostics follow. Both the input and decomposed diagonal are printed. Only available when module SDCMPS is used.

2378 *** USER INFØRMATION MESSAGE 2378, **** ESTIMATE ØF CPU TIME FØR MT=****, PASSIVE CØL.=****, ACTIVE CØL.=****, SPILL=****.

Seconds of CPU time for each of the above operations is given when module SDCMPS is used.

2379 *** SYSTEM WARNING MESSAGE 2379, FILE **** CØULD NØT BE ØPENED IN SDCMQ. CØLUMN **** SINGULAR, REASØN ****.

During queuing of singularities using module SDCMPS the files were incorrect. The reasons are numbered as follows:

1. null column, input matrix
2. zero diagonal, decomposed diagonal
3. negative diagonal, decomposed diagonal
4. exceeded singularity tolerance, decomposed matrix
5. unexpected null column during decomposition
6. nonconservative column (decomposed diagonal/input diagonal > 1.001).
7. zero diagonal, input matrix

2380 *** USER WARNING MESSAGE 2380, MULTIPØINT CØNSTRAINT FØRCES NØT ØUTPUT IN ******, SEE QUEUED MESSAGES.

Other message(s) follow(s) indicating the reason(s) why a request for MPCFØRCE in Case Control deck is being ignored.

2382 *** USER WARNING MESSAGE 2382, ELEMENT MATRICES FØR ELEMENTS CØNGRUENT TØ ELEMENT ID = ***** ***** WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ HØLD CØNGRUENCY MAPPING DATA.

2383 *** SYSTEM WARNING MESSAGE 2383, UNABLE TØ LØCATE CØNGRUENCY MAPPING DATA FØR ELEMENT ID = **********. ELEMENT MATRICES FØR THIS ELEMENT WILL, THEREFØRE, BE RE-CØMPUTED.

2384 *** USER WARNING MESSAGE 2384, CØNGRUENCY ØF ELEMENT ID = ********** WILL BE IGNØRED AND ITS ELEMENT MATRICES WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS TIME TØ PERFØRM CØNGRUENCY MAPPING CØMPUTATIØNS.

2385 *** USER WARNING MESSAGE 2385, DESIRED NUMBER ØF EIGENVALUES EXCEED THE EXISTING NUMBER, ALL EIGENSØLUTIØNS WILL BE SØUGHT.

The desired number of eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) exceeds the rank of the $[K^d_{aa}]$ or $[M_{aa}]$ matrix.

2386 *** USER FATAL MESSAGE 2386, STIFFNESS MATRIX SINGULARITY CANNØT BE REMØVED BY SHIFTING.

Check the specification of masses on CØNM1, CØNM2, CMASSi, material definition and element property cards to ensure that the degrees-of-freedom in the analysis set are not all massless.

2387 *** USER WARNING MESSAGE 2387, PRØBLEM SIZE REDUCED TØ **** DUE TØ ØRTHØGØNALITY DRIFT ØR NULL TRIAL VECTØR.
ALL EXISTING MØDES MAY HAVE BEEN ØBTAINED. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The Tridiagonal Reduction method cannot generate a reduced problem size of the order prescribed in Section 10.6.2.3 of the Theoretical Manual. However, the desired number of accurate eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) may have been obtained. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK.

2388 *** USER WARNING MESSAGE 2388, USER SPECIFIED RANGE NØT USED FØR FEER BUCKLING, THE RØØTS ØF LØWEST MAGNITUDE ARE ØBTAINED.

The value of L1 specified on the EIGB card is ignored for buckling analysis by the Tridiagonal Reduction (FEER) method.

2389 *** USER WARNING MESSAGE 2389, PRØBLEM SIZE REDUCED. NØ MØRE TRIAL VECTØRS CAN BE ØBTAINED.

The desired number of eigenvalues specified on the EIGB card (NEP) or the EIGR card (ND) exceeds the number that can be calculated by the Tridiagonal Reduction (FEER) method Check whether the requested number of eigenvalues exceeds the rank of the $[K^d_{aa}]$ or $[M_{aa}]$ matrix, which equals the number of existing eigenvalues.

2390 *** USER WARNING MESSAGE 2390, **** FEWER ACCURATE EIGENSØLUTIØNS THAN THE **** REQUESTED HAVE BEEN FØUND. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The number of eigenvalues passing the eigenvalue relative-error test is less than the number requested on the EIGB or EIGR card. The maximum allowable error is specified in field 5 on the above cards. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK. A checkpoint and restart should be employed to obtain additional accurate eigensolutions.

2391 *** SYSTEM FATAL MESSAGE 2381, PRØGRAM LØGIC ERRØR IN FEER.

An unexpected EØF or word count has been encountered. This is caused by a conflict between subroutine FCNTL and GINØ.

2392 *** USER INFØRMATIØN MESSAGE 2392, **** MØRE ACCURATE EIGENSØLUTIØNS THAN THE **** REQUESTED HAVE BEEN FØUND. USE DIAG 16 TØ DETERMINE ERRØR BØUNDS.

The number of eigenvalues passing the eigenvalue relative-error test is greater than the number requested on the EIGB or EIGR card. The maximum allowable error is specified in field 5 on the above cards. A detailed list of the computed error bounds could have been obtained by requesting DIAG 16 in the EXECUTIVE CØNTRØL DECK.

2393 *** USER WARNING MESSAGE 2393, THE REDUCED-SYSTEM EIGENVECTØR CØRRESPØNDING TØ EIGENVALUE **** DØES NØT MEET CØNVERGENCE CRITERIØN. ABSØLUTE RELATIVE ERRØR BETWEEN SUCCESSIVE ITERATES IS ****.

The accuracy of the corresponding physical eigenvector is in doubt. Refer to the Eigenvalue Summary Table for the largest error in the generalized mass matrix.

2396 *** USER WARNING MESSAGE 2396, DSCØMP CØMPUTED A ZERØ ØN THE DIAGØNAL. A VALUE ØF 1.0E-10 WILL BE USED. THE ACCURACY ØF THE DECØMPØSITIØN MAY BE IN DØUBT.

The matrix being decomposed is singular or a diagonal element is less than zero in the case of Cholesky decomposition.

2397 *** USER FATAL MESSAGE 2397, INVALID TØ HAVE AN Ø-SET WITH A NULL A-SET

There must be at least one degree of freedom in the A-SET even though EPØINTS may be present.

2399 *** USER WARNING MESSAGE 2399, ONLY THE FIRST ***** EIGENSØLUTIØNS CLØSEST TØ THE SHIFT PØINT (F1 ØR ZERØ) PASS THE FEER ACCURACY TEST FØR EIGENVECTØRS.

2401 *** USER WARNING MESSAGE 2401, ******** MATRIX IS NULL. AN ARBITRARY VALUE ØF 1.0 IS THEREFØRE ASSIGNED TØ THE RIGID BØDY ERRØR RATIØ (EPSILØN SUB E).

2402 *** USER FATAL MESSAGE 2402, NULL DIFFERENTIAL STIFFNESS MATRIX GENERATED IN SUBRØUTINE DS1A.

2404 *** USER FATAL MESSAGE 2404, GRID PØINTS 1 AND 3 ØF TRIM6 WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2405 *** USER FATAL MESSAGE 2405, GRID PØINTS 1, 3, AND 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRIM6 WITH ID = ********.

2406 *** USER FATAL MESSAGE 2406, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRIM6 WITH ID = ********.

2407 *** USER FATAL MESSAGE 2407, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES OF ELEMENT TRIM6 WITH ID = ********.

2408 *** USER FATAL MESSAGE 2408, GRID PØINTS 1 AND 3 OF TRPLT1 WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2409 *** USER FATAL MESSAGE 2409, GRID PØINTS 1, 3, and 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRPLT1 WITH ID = ********.

2410 *** USER FATAL MESSAGE 2410, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRPLT1 WITH ID = ********.

2411 *** USER FATAL MESSAGE 2411, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES ØF ELEMENT TRPLT1 WITH ID = ********.

2412 *** USER FATAL MESSAGE 2412, A SINGULAR MATERIAL MATRIX FØR ELEMENT ID = ******** HAS BEEN DETECTED BY SUBRØUTINE TLQDT1 WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The thermal load vector generated by TEMPP2 data is not correctly applied to a TRPLT1 element.

2413 *** USER FATAL MESSAGE 2413, GRID PØINTS 1 AND 3 ØF TRSHL WITH ELEMENT ID = ******** HAVE SAME CØØRDINATES.

2414 *** USER FATAL MESSAGE 2414, GRID PØINTS 1, 3, AND 5 APPEAR TØ BE ØN A STRAIGHT LINE. ELEMENT TRSHL WITH ID = ********.

2415 *** USER FATAL MESSAGE 2415, GRID PØINTS 1 AND 5 HAVE SAME CØØRDINATES. ELEMENT TRSHL WITH ID = ********.

2416 *** USER FATAL MESSAGE 2416, MATRIX RELATING GENERALIZED PARAMETERS AND GRID PØINT DISPLACEMENTS IS SINGULAR. CHECK CØØRDINATES ØF ELEMENT TRSHL WITH ID = ********.

2417 *** USER FATAL MESSAGE 2417, A SINGULAR MATERIAL MATRIX FØR ELEMENT ID = ******** HAS BEEN DETECTED BY SUBRØUTINE TLØDSL WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The thermal load vector generated by TEMPP2 data is not correctly applied to a TRSHL element.

2418 *** USER FATAL MESSAGE 2418, MATERIAL ID FØR MEMBRANE EFFECTS IS LESS THAN ØR EQUAL TØ ZERØ FØR TRSHL ELEMENT WITH ID = ********.

2419 *** SYSTEM FATAL MESSAGE 2419, PIVØT PØINT IS NØT EQUAL TØ TRSHL ELEMENT GRID PØINTS FØR ELEMENT ID = ********.

An error in the coordinate system tranformation has occurred. Temporary avoidance: remove coordinate system ID from field 7 of the GRID (or GRDSET) card.

2422 *** USER WARNING MESSAGE 2422, VISC DATA NØT PRØCESSED BY EMGPRØ.

CVISC data cards are used only in the direct method of dynamic problem formulations (Rigid Formats 7, 8, and 9). A warning is issued when these cards are encountered in the modal method of dynamic problem formulations (Rigid Formats 10, 11, and 12).

2423 *** USER FATAL MESSAGE 2423, DEPENDENT CØMPØNENT SPECIFIED MØRE THAN ØNCE ØN MPC CARDS AND/ØR IN RIGID ELEMENTS.
SIL VALUE = ********

The use of DIAG 21 in the Executive Control Deck will show the SIL (internal DØF) corresponding to the duplicated component.

2424 *** USER FATAL MESSAGE 2424, MACH BØX CØNTRØL PØINTS IMPRØPER. SINGULAR MATRIX RESULTED.

2425 *** USER FATAL MESSAGE 2425, MACH BØX GENERATIØN ØF BØXES FAILED.

2426 *** USER FATAL MESSAGE 2426, MACH NUMBER ********** WAS NØT FØUND ØN AEFACT CARD ********.

2427 *** USER FATAL MESSAGE 2427, SINGULAR MATRIX FØR INTERPØLATIØN IN ********.

2428 *** USER FATAL MESSAGE 2428, MACH NUMBER ********** WAS NØT FØUND IN PISTØN THEØRY ALPHA ARRAY.

2429 *** USER FATAL MESSAGE 2429, WRØNG NUMBER ØF WØRDS ØR CARD NØT FØUND FØR CARD ID ******** ASSØCIATED WITH CAERØ* ID ********.

3001 *** SYSTEM FATAL MESSAGE 3001, ATTEMPT TØ ØPEN DATA SET *** IN SUBRØUTINE ****** WHICH WAS NØT DEFINED IN FIST.

Subroutine did not expect data block to be purged. Check data block requirements for module. This message is also a WARNING when STRESS output is requested in a heat transfer problem.

3002 *** SYSTEM FATAL MESSAGE 3002, EØF ENCØUNTERED WHILE READING DATA SET ********(FILE ***) IN SUBRØUTINE ******.

This message is issued when and End-Of-File occurs while trying to skip the header record. The data block is not in the proper format.

3003 *** SYSTEM FATAL MESSAGE 3003, ATTEMPT TØ READ PAST THE END ØF A LØGICAL RECØRD IN DATA SET ********(FILE ***) IN SUBRØUTINE ******.

This message is issued when the file is positioned at the beginning of a logical record and the record does not contain at least three words. Data block is not in proper format.

3004 *** SYSTEM FATAL MESSAGE 3004, INCONSISTENT TYPE FLAGS ENCOUNTERED WHILE PACKING DATA SET ****.

3005 *** USER FATAL MESSAGE 3005, ATTEMPT TØ ØPERATE ØN SINGULAR MATRIX **** IN SUBRØUTINE ****.

A diagonal term does not exist for a column of (U). This is normally detected in DECØMP implying care was not taken in processing singular matrices in the calling routine.

3006 *** SYSTEM FATAL MESSAGE 3006, BUFFER ASSIGNED WHEN ØPENING DATA BLØCK **** FILE (****) CØNFLICTS WITH BUFFERS CURRENTLY ØPEN.

Computation of buffer pointers or allocation of open core is in error.

3007 *** SYSTEM FATAL MESSAGE 3007, ILLEGAL INPUT TØ SUBRØUTINE ****.

Subroutine **** has encountered data which it cannot process. This error should not be caused by user input data. A system or programming error is indicated. Go directly to the subroutine listing or description to determine the exact cause of the problem.

3008 *** SYSTEM FATAL MESSAGE 3008, INSUFFICIENT CØRE AVAILABLE FØR SUBRØUTINE ********.

This message implies that the particular subroutine does not have sufficient core to meet its demands. The subroutine or module description should be consulted to determine the core requirements.

3009 *** SYSTEM FATAL MESSAGE 3009, DATA TRANSMISSIØN ERRØR ØN DATA SET *******(FILE ***).

A conflict exists between the SGINØ subroutine for the UNIVAC 1108 and the resident NTRAN$. Either record SGINØ or remove the PLØT request from the NASTRAN job.

3010 *** SYSTEM FATAL MESSAGE 3010, ATTEMPT TØ MANIPULATE DATA SET ********(FILE ***) BEFØRE ØPENING FILE.

An operation other than ØPEN or CLØSE is requested on a file which is not defined in the FIST.

3031 Same as message 3032.

3032 *** USER FATAL MESSAGE 3032, UNABLE TØ FIND SELECTED SET (****) IN TABLE (****) IN SUBRØUTINE (****).

A particular set used in the problem was not included in the data. Good examples are loads, initial conditions, or frequency sets. Include the required data or change the Case Control Deck to select data already in problem. Set zero (0) has a special meaning. A set selection was required, but none was made. For example, no METHØD was selected for an eigenvalue extraction problem.

This message can also indicate that a LØAD card has referenced another LØAD card, which is not permitted.

3033 *** USER FATAL MESSAGE 3033, SUBCASE ID **** IS REFERENCED ØN ØNE ØR MØRE RANDPS CARDS BUT IS NØT A CURRENT SUBCASE ID.

The RANDPS set selected can only reference subcase identification numbers included in the current loop. All subcases in which the direct input matrices or transfer functions do not change are run together. Either add a subcase with referenced identification number, change your RANDPS cards or change the identification numbers on your current subcases.

3034 *** USER WARNING MESSAGE 3034, ØRTHØGØNALITY CHECK FAILED, LARGEST TERM = **** EPSI = ****.

The off-diagonal terms of the modal mass matrix are larger than the user input criteria on the EIGB or EIGR bulk data card. The eigenvectors are not orthogonal to this extent. This nonorthogonality is especially important if a modal formulation is contemplated.

3035 *** USER INFØRMATIØN MESSAGE 3035, FØR LØAD ** EPSILØN SUB E=*****.

This is an informative message reflecting the accumulated round-off error of the static solution.

3036 *** SYSTEM FATAL MESSAGE 3036, DATA SET ******** IS REQUIRED AS INPUT BUT HAS NØT BEEN GENERATED ØR PURGED.

The above mentioned data set is not accounted for on the ØPTP checkpoint dictionary. The message indicates a failure of the File Name Table. As an interim measure the user can use the ALTER feature to execute the proper module to create the needed data set.

3037 *** SYSTEM FATAL MESSAGE 3037, JØB TERMINATED IN SUBRØUTINE ****.

This message designates the subroutine in which the program terminated. It should be preceeded by a user message which explains the cause of the termination. The module in which the program terminated can be found by examining the online time messages.

3038 *** SYSTEM FATAL MESSAGE 3038, DATA SET *** DØES NØT HAVE MULTIREEL CAPABILITY.

Computer hardware/software does not support multireel files.

3039 *** SYSTEM FATAL MESSAGE 3039, ENDSYS CANNØT FIND SAVE FILE.

File cannot be found to save and restore executive tables during link switching.

3040 *** SYSTEM FATAL MESSAGE 3040, ATTEMPT TØ WRITE DATA SET ********(FILE ***) WHEN IT IS AN INPUT FILE.

Input data blocks for a module (100 .LT. NAME .LT. 200) may be read only.

3041 *** USER WARNING MESSAGE 3041, EXTERNAL GRID PØINT *** DØES NØT EXIST ØR IS NØT A GEØMETRIC GRID PØINT. THE BASIC ØRIGIN WILL BE USED.

The reference grid point specified on the PARAM GRDPNT card for weight and balance calculations in GPWG cannot be used.

3042 *** USER WARNING MESSAGE 3042, INCØNSISTENT SCALAR MASSES HAVE BEEN USED. EPSILØN/DELTA = *****.

The GPWG has detected inconsistant scalar masses. Direct masses have been used. Skew inertia's will result. Examine your scalar masses and CØNM1 cards.

3043 *** USER FATAL MESSAGE 3043, UNCØNNECTED EXTRA PØINT (MØDAL CØØRDINATE=***) HAS BEEN DETECTED BY SUBRØUTINE ****.

Extra points must be connected via Direct Matrix Input (or Transfer Functions) in modal transient or frequency response.

3044 *** USER FATAL MESSAGE 3044, A PØINT ØN NØNLINEAR LØAD SET **** NØLIN **** IS NØT AN EXTRA PØINT. ØNLY EXTRA PØINTS MAY HAVE NØNLINEAR LØADS IN A MØDAL FØRMULATIØN.

Modal transient analysis (Rigid Format D-12) will support nonlinear loads only on extra points. Pick another nonlinear load set.

3045 *** USER WARNING MESSAGE 3045, INSUFFICIENT TIME TØ CØMPLETE THE REMAINING ** SØLUTIØN(S) IN MØDULE ***.

The time specified on the NASTRAN TIME card has expired in the named module. The module will be terminated. NASTRAN will continue running until the time on the job card expires. Restart to obtain print-out, complete solutions or rerun problem.

3046 *** USER FATAL MESSAGE 3046, YØUR SELECTED LØADING CØNDITIØN, INITIAL CØNDITIØN, AND NØNLINEAR FØRCES ARE NULL. A ZERØ SØLUTIØN WILL RESULT.

Transient solution must have one of the above nonzero.

3047 *** USER FATAL MESSAGE 3047, NØ MØDES WITHIN RANGE AND LMØDES=0. A MØDAL FØRMULATIØN CANNØT BE MADE.

The modes used for a modal formulation must be selected by a PARAM card. Set LFREQ, HFREQ or LMØDES to request modes.

3048 *** SYSTEM FATAL MESSAGE 3048, BUFFER CØNTRØL WØRD INCØRRECT FØR GINØ **** ØPERATIØN ØN DATA BLØCK ****.

The buffer control word has been destroyed outside of GINØ or an attempt to READ a file opened to WRITE or similar error has occurred.

3049 *** SYSTEM FATAL MESSAGE 3049, GINØ UNABLE TØ PØSITIØN DATA BLØCK **** CØRRECTLY DURING **** ØPERATIØN.

A block number read does not match the expected block number. The file has been repositioned outside the GINØ environment or a machine or operating system error has occurred.

3050 *** USER FATAL MESSAGE 3050, INSUFFICIENT TIME REMAINING FØR DECØMPØSITIØN, ****. TIME ESTIMATE IS **** SECONDS.

The time estimated for a decomposition exceeds the remaining time. Increase the time estimate for the run.

3051 *** USER FATAL MESSAGE 3051, INITIAL CØNDITIØN SET **** WAS SELECTED FØR A MØDAL TRANSIENT PRØBLEM. INITIAL CØNDITIØNS ARE NØT ALLØWED IN SUCH A PRØBLEM.

3052 *** USER WARNING MESSAGE 3052, A RANDØM REQUEST FØR CURVE TYPE - **** -, PØINT - **** CØMPØNENT - **** -, SPECIFIES TØØ LARGE A CØMPØNENT ID. THE LAST CØMPØNENT WILL BE USED.

3053 *** USER WARNING MESSAGE 3053, THE ACCURACY ØF EIGENVALUE **** IS IN DØUBT. GIVENS-QR FAILED TØ CØNVERGE IN **** ITERATIØNS.

Each eigenvalue is computed to the precision limits of each machine consistent with the maximum number of iterations allowed. A programming change would be required to increase the maximum iteration parameter.

3054 *** USER WARNING MESSAGE 3054, THE ACCURACY ØF EIGENVECTØR **** CØRRESPØNDING TØ THE EIGENVALUE **** IS IN DØUBT.

The eigenvector failed to converge in the allowable number of iterations. Particular attention should be given to the off-diagonal terms of the modal mass matrix (MI) to determine if this vector is orthogonal to the remaining vectors. These terms will be computed and checked if field 9 on the EIGR card contains a nonzero value. The message is expected in the case of close or multiple eigenvalues, even though the vectors are properly computed.

3055 *** USER FATAL MESSAGE 3055, AN ATTEMPT TØ MULTIPLY ØR MULTIPLY AND ADD NØN-CØNFØRMABLE MATRICES TØGETHER WAS MADE IN SUBRØUTINE ********.

The multiply/add subroutine requires conformable matrices. There are two possible equations

1. $[X] = [A][B] + [C]$

The number of columns of [A] must be equal to the number of rows of [B] and the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of rows of [A].

2. $[X] = [A]^T[B] + [C]$

The number of rows of [A] must be equal to the number of rows of [B]; the number of columns of [C] must be equal to the number of columns of [B] and the number of rows of [C] must be equal to the number of columns of [A].

3056 *** USER FATAL MESSAGE 3056, NØ MASS MATRIX IS PRESENT BUT MASS DATA IS REQUIRED.

An operation with the mass matrix is required, such as a gravity loading condition, but none was created. A typical cause is the omission of RHØ on the MAT1 card.

3057 *** USER FATAL MESSAGE 3057, MATRIX **** IS NØT PØSITIVE DEFINITE.

A Cholesky decomposition was attempted on the above matrix, but a diagonal term was negative or equal to zero, such that the decomposition failed.

3058 *** USER WARNING MESSAGE 3058, EPSILØN IS LARGER THAN **** FØR SUBCASE ****.

The error residual (either ϵ_ℓ or ϵ_ϕ)

$$\epsilon = \frac{\{u\}^T \{\delta P\}}{\{P\}^T \{u\}}$$ is larger than would be expected for

a well conditioned problem. Near singularities may exist.

3059 *** USER FATAL MESSAGE 3059, SET IDENTIFIER **** DØES NØT EXIST. ERRØR DETECTED IN SUBRØUTINE ****.

When describing displacement matrices only those set identifier (such as M or G) listed in DMAP module MATGPR are legal set descriptors. Choose a set descriptor which is legal (and describes the matrices to be operated on).

3060 *** USER FATAL MESSAGE 3060, READ MØDULE FINDS THAT THE INPUT STIFFNESS AND/ØR MASS MATRIX IS NULL.

3061 *** USER INFØRMATIØN MESSAGE 3061, THE MEASURE ØF NØN- PLANARITY IS **** FØR ELEMENT NUMBER ********.

The measure of non-planarity for isoparametric quadrilateral membrane elements is the distance from actual grid points to mean plane divided by the average length of the diagonals. This message is issued only when the absolute value of this measure is greater than .01.

3062 *** SYSTEM FATAL MESSAGE 3062, HMAT MATERIAL RØUTINE CALLED IN A NØN-HEAT-TRANSFER PRØBLEM.

3063 *** SYSTEM WARNING MESSAGE 3063, INPUT FØRCES DATSDRHA BLØCK DØES NØT HAVE CØRRECT DATA.

3064 *** SYSTEM WARNING MESSAGE 3064, INCØNSISTENT HBDY DATA RECØRDS. ********** **********

3065 *** SYSTEM WARNING MESSAGE 3065, THERE IS NØ EST DATA FØR HBDY ELEMENT ID = **********.

3066 *** USER WARNING MESSAGE 3066, THERE IS NØ TLØAD1 ØR TLØAD2 DATA FØR LØAD-ID = **********.

3067 *** USER WARNING MESSAGE 3067, LØAD SET ID = ********** IS NØT PRESENT.

3068 *** SYSTEM WARNING MESSAGE 3068, UNRECØGNIZED CARD TYPE = ********** FØUND IN -SLT- DATA BLØCK.

3069 *** USER WARNING MESSAGE 3069, ØUTPUT DATA BLØCK FØR FØRCES IS PURGED.

3070 *** USER WARNING MESSAGE 3070, QGE IS REQUIRED BY THIS MØDULE AND IS PURGED. NØ ØUTPUT FILE HAS BEEN CREATED.

3071 *** SYSTEM WARNING MESSAGE 3071, EXTRA DATA IN RADLST RECØRD ØF MATPØØL DATA BLØCK IGNØRED.

3072 *** USER WARNING MESSAGE 3072, TØØ MANY MATRIX VALUES INPUT VIA RADMIX BULK DATA FØR CØLUMN ********. EXTRA VALUES IGNØRED AS MATRIX SIZE IS DETERMINED TØ BE ØF SIZE ******** FRØM RADLST CØUNT ØF ELEMENT ID-S.

3073 *** USER FATAL MESSAGE 3073, NØ -HBDY- ELEMENT SUMMARY DATA IS PRESENT FØR ELEMENT ID = ********, WHICH APPEARS ØN A -RADLST- BULK DATA CARD.

3074 *** USER FATAL MESSAGE 3074, CØLUMN ******** ØF THE Y MATRIX IS NULL.

3075 *** USER FATAL MESSAGE 3075, INTERMEDIATE MATRIX Y IS SINGULAR.

3076 *** SYSTEM FATAL MESSAGE 3076, GPTT DATA IS NØT IN SØRT BY INTERNAL ID.

3077 *** USER FATAL MESSAGE 3077, THERE IS NØ GRID PØINT TEMPERATURE DATA ØR DEFAULT TEMPERATURE DATA FØR SIL PØINT ******** AND PØSSIBLY ØTHER PØINTS.

3078 *** USER FATAL MESSAGE 3078, NØ GPTT DATA IS PRESENT FØR TEMPERATURE SET ********.

3079 *** USER FATAL MESSAGE 3079, THERE ARE NØ -HBDY- ELEMENTS PRESENT.

3080 *** USER FATAL MESSAGE 3080, INTEGER VALUES ØF EMISSIVITY ENCØUNTERED ********** ELEMENT ID = **********.

3081 *** SYSTEM FATAL MESSAGE 3081, INCØNSISTENT USET DATA DETECTED.

3082 *** USER WARNING MESSAGE 3082, M = **********, N = **********.

More than one n-set degree-of-freedom is associated with an m-set degree-of-freedom. The set relationship to be used is indicated in the message.

3083 *** USER FATAL MESSAGE 3083, UM PØSITIØN = **********, SIL = **********.

An m-set degree-of-freedom is not expressed in terms of an n-set degree-of-freedom.

3084 *** USER FATAL MESSAGE 3084, THERE IS NØ TEMPERATURE DATA FØR SIL NUMBER **********.

3085 *** USER FATAL MESSAGE 3085, THE PF LØAD VECTØR IS EITHER PURGED ØR NULL.

3086 (1) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 1 (NØRMAL CØNVERGENCE).

3086 (2) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 2 (MAXIMUM ITERATIØNS).

3086 (3) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 3 (DIVERGING SØLUTIØN).

3086 (4) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 4 (INSUFFICIENT TIME).

3086 (5) *** USER INFØRMATIØN MESSAGE 3086, ENTERING SSGHT EXIT MØDE BY REASØN NUMBER 5 (MAXIMUM CØNVERGENCE).

1. Normal convergence occurs when the solution meets the convergence criteria defined by the parameter EPSHT.
2. Iterations are terminated when the number defined by the parameter MAXIT is attained.
3. Iterations are terminated when the solution diverges.
4. Iterations are terminated when there is insufficient time to complete the next loop.
5. Iterations are terminated when there is no change to the solution vector but the parameter EPSHT criteria was not met.

3087 *** USER FATAL MESSAGE 3087, TEMPERATURE SET ********** IS NØT PRESENT IN GPTT DATA BLØCK.

3088 *** USER FATAL MESSAGE 3088, ILLEGAL GEØMETRY FØR REVØLUTION ELEMENT ****.

3089 *** USER FATAL MESSAGE 3089, ILLEGAL GEØMETRY FØR TRIANGLE ELEMENT ****.

3090 *** USER FATAL MESSAGE 3090, ILLEGAL GEØMETRY FØR QUAD. ELEMENT ****.

3091 *** SYSTEM WARNING MESSAGE 3091, A TRAPRG ELEMENT = ************** DØES NØT HAVE SIDE 1-2 PARALLEL TØ SIDE 3-4.

3092 *** USER FATAL MESSAGE 3092, TRIARG ØR TRAPRG ELEMENT = ************* PØSSESSES ILLEGAL GEØMETRY.

3093 *** SYSTEM FATAL MESSAGE 3093, ELEMENT = ******** REASØN = ******.

A thermal load (via QVØL card) can not be computed because

1. Less than 2 points have been referenced.
2. Unable to locate SIL value.
3. Unrecognizable form for element.

(1–3: Rods; triangular or quadrilateral membranes, plates, or rings; solid hexahedra.)

4. Illegal number of points for triangular or quadrilateral membranes, plates, or rings.
5. Illegal number of points for solid hexahedra.

3094 *** SYSTEM FATAL MESSAGE 3094, SLT LØAD TYPE ********** IS NØT RECØGNIZED.

3095 *** USER WARNING MESSAGE 3095, ELEMENT TYPE *********** WITH ID = *********, AND APPEARING ØN EITHER A QVECT, QBDY1, QBDY2, ØR QVØL LØAD CARD HAS THE SAME ID AS AS ELEMENT ØF ANØTHER TYPE AND IS NØT BEING USED FØR LØADING.

3096 *** USER FATAL MESSAGE 3096, ELEMENT ID = ********** AS REFERENCED ØN A QVØL, QBDY1, QBDY2, ØR QVECT LØAD CARD CØULD NØT BE FØUND AMØNG ACCEPTABLE ELEMENTS FØR THAT LØAD TYPE.

3097 *** USER FATAL MESSAGE 3097, CØLUMN ****** IS SINGULAR. UNSYMMETRIC ******** DECØMP
(1) ABØRTED.

3097 *** USER FATAL MESSAGE 3097, SYMMETRIC DECØMPØSITIØN ØF DATA BLØCK ******** ABØRTED BECAUSE
(2) THE FOLLOWING COLUMNS ARE SINGULAR --

When a matrix being read in is singular (null column or for symmetric decomposition a zero diagonal) the internal column number and type of decomposition is identified. The message does not appear for special cases such as less than three columns or for proportional rows.

3098 *** USER FATAL MESSAGE 3098, QDMEM2 ELEMENT STIFFNESS RØUTINE DETECTS ILLEGAL GEØMETRY FØR ELEMENT ID = **********.

3099 *** USER FATAL MESSAGE 3099, ELEMENT STIFFNESS CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** IS IMPØSSIBLE DUE TØ SINGULARITY IN CØNSTRAINT EQUATIØN.

3100 *** USER WARNING MESSAGE 3100, ELEMENT THERMAL LØAD CØMPUTATIØN FØR QDMEM2 ELEMENT ID = ********** FINDS ILLEGAL GEØMETRY THUS NØ LØADS ØUTPUT FØR ELEMENT-ID NØTED.

3101 *** USER WARNING MESSAGE 3101, SINGULARITY ØR BAD GEØMETRY FØR QDMEM2 ELEMENT ID = ********* STRESS ØR FØRCES WILL BE INCØRRECT.

3102 (1) *** SYSTEM FATAL MESSAGE 3102. LØGIC ERRØR EMA- ****.

3102 (2) *** USER WARNING MESSAGE 3102, SUBRØUTINE TRHTIC, UNSTABLE TEMP. VALUE ØF *************** ****, CØMPUTED FØR TIME STEP ***** AT PØINT NUMBER ****** IN THE ANALYSIS STEP.

3103 (1) *** USER WARNING MESSAGE 3103. EMGCØR ØF EMG MØDULE FINDS EITHER ØF DATA BLØCKS **** ØR **** ABSENT AND THUS ****, MATRIX WILL NØT BE FØRMED.

3103 (2) *** USER FATAL MESSAGE 3103, SUBRØUTINE TRHTIC TERMINATING DUE TØ ERRØR CØUNT FØR MESSAGE 3102.

This occurs for 10 errors detected in the temperature computation.

3104 *** SYSTEM WARNING MESSAGE 3104. EMGCØR FINDS SET (ASSUMED DATA BLØCK *****) MISSING. EMG MØDULE CØMPUTATIØNS LIMITED.

3105 *** SYSTEM FATAL MESSAGE 3105. EMGPRØ FINDS ELEMENT ØF TYPE = ******** ******** UNDEFINED IN EST DATA BLØCK AND/ØR ELEMENT RØUTINE.

3106 *** SYSTEM FATAL MESSAGE 3106. EMGPRØ FINDS THAT ELEMENT TYPE ********** HAS EST ENTRIES TØØ LARGE TØ HANDLE CURRENTLY.

3107 *** SYSTEM INFØRMATIØN MESSAGE 3107. EMGØLD IS PRØCESSING ELEMENTS ØF TYPE = ***, BEGINNING WITH ELEMENT ID = **********.

3108 *** SYSTEM FATAL MESSAGE 3108. EMGØUT RECEIVES ILLEGAL FILE TYPE = **********.

3109 *** SYSTEM FATAL MESSAGE 3109. EMGØUT HAS BEEN SENT AN INVALID DICTIØNARY WØRD-2 = ********** FRØM ELEMENT ID = **********.

3110 *** SYSTEM FATAL MESSAGE 3110. EMGØUT HAS BEEN CALLED TØ WRITE AN INCØRRECT NUMBER ØF WØRDS FØR ELEMENT ID = **********.

3111 *** SYSTEM FATAL MESSAGE 3111. INVALID NUMBER ØF PARTITIØNS WERE SENT EMGØUT FØR ELEMENT ID = ********** WITH RESPECT TØ DATA BLØCK TYPE = ***.

3112 *** USER INFØRMATION MESSAGE 3112. ELEMENTS CØNGRUENT TØ ELEMENT ID = ********** WILL BE RE-CØMPUTED AS THERE IS INSUFFICIENT CØRE AT THIS MØMENT TØ HØLD DICTIØNARY DATA.

3113A*** SYSTEM INFØRMATIØN MESSAGE 3113. EMGPRØ PRØCESSING **** PRECISIØN ELEMENTS ØF TYPE ******** STARTING WITH ID ********.

3113B*** SYSTEM WARNING MESSAGE 3113, EMGØLD HAS RECEIVED A CALL FØR ELEMENT ********** WHICH IS ØF ELEMENT TYPE ********** AND NØT HANDLED BY EMGØLD. ELEMENT IGNØRED.

3114 *** SYSTEM FATAL MESSAGE 3114, EMGØLD CØMPATIBILITY RØUTINE CAN NØT HANDLE THE QUANTITY ØF CØNNECTIØNS FØR SILS ELEMENT **********.

3115 *** USER WARNING MESSAGE 3115, EMGØLD FINDS ELEMENT TYPE ********** PRESENT IN A HEAT FØRMULATIØN AND IS IGNØRING SAME.

This includes CQDMM1, CCØNEAX, CTØRDRG, CTRAPAX, CTRIAAX, CFLUID1, CSLØT, CSHEAR, CTRBSC, and CTRPLT elements.

3116 *** SYSTEM FATAL MESSAGE 3116, ELEMENT ID ********** SENDS BAD SIL TØ RØUTINE EMG1B.

3118 *** USER FATAL MESSAGE 3118, RØD ELEMENT NØ. ********** HAS ILLEGAL GEØMETRY ØR CØNNECTIØNS.

3119 *** USER FATAL MESSAGE 3119, INSUFFICIENT CØRE TØ PRØCESS RØD ELEMENTS.

3120 *** USER WARNING MESSAGE 3120, IMPRØPER CØNNECTIØN ØN CELAS ELEMENT, **********.

3123 *** USER FATAL MESSAGE 3123, PARAMETER NUMBER ***** NØT IN DMAP CALL.

3124 *** USER FATAL MESSAGE 3124, PARAMETER NUMBER ***** IS NØT A VARIABLE.

3125 *** SYSTEM FATAL MESSAGE 3125, INVALID TABLE NUMBER. **********, IS NØ. *****, ØF *****, PASSED TO PRETABLE.

3128 *** SYSTEM WARNING MESSAGE 3128, **** **** AND **** **** ARE EQUIVALENT LABELS. CØNSULT BØTH FØR INTERCHANGEABLE XREF.

3129 *** USER FATAL MESSAGE 3129, SDR3 CAN ØNLY PRØCESS 30 ELEMENT TYPES, PRØBLEM HAS ***.

The total of 30 different element types includes the sum of the different types of structural/scalar elements plus the different types of user's DUMMY elements.

3130 *** SYSTEM FATAL MESSAGE 3130, LØGIC ERRØR ****** ØCCURRED IN SDCØMP. CØNTENTS ØF /SDCØMX/ FØLLØW --

Numerous error conditions exist in subroutine SDCØMP. The current value in the error message helps the programmer to specifically locate the area of the code where the error occurred. Common block SDCØMX is dumped in case DIAG 1 was not on.

3131 *** USER FATAL MESSAGE 3131, INPUT STIFFNESS AND MASS MATRICES ARE NØT CØMPATIBLE.

The matrices must be the same size to properly perform matrix operations.

3132 *** SSGHT RECØVERING FRØM SEVERE USER CØNVERGENCE CRITERIA.

A nonlinear heat transfer solution cannot converge because the value for EPSHT on a PARAM card is too small. Either change the value to one which requires less accuracy or provide for a greater number of iterations (MAXIT on another PARAM card) to allow the solution to converge.)

3133 *** USER FATAL MESSAGE 3133, LENGTH ØF CRIGDR (RIGID RØD) ELEMENT ******** IS ZERØ.

The end grid points of the element cannot be coincident.

3134 *** USER FATAL MESSAGE 3134, CRIGDR (RIGID RØD) ELEMENT ******** IS NØT PRØPERLY DEFINED.

The direction defined by the dpeendent translational degree of freedom cannot be perpendicular (or nearly perpendicular) to the element.

3143 *** USER INFØRMATIØN MESSAGE 3143, THE EIGENVALUES AND EIGENVECTØRS FØUND ØN THIS RESTART WILL BE APPENDED TØ THE ******** EIGENVALUES AND EIGENVECTØRS PREVIØUSLY CHECKPØINTED.

This message is generated when the APPEND feature is being used in the case of the Determinant, Inverse Power, and FEER methods of real eigenvalue extraction.

3144 *** USER WARNING MESSAGE 3144, MØDULE EMG FINDS ELEMENT TYPE ******** PRESENT IN A HEAT FORMULATIØN AND IS REPLACING IT WITH ELEMENT TYPE CQDMEM.

In a HEAT formulation, element types CQDMEM1 and CQDMEM2 are automatically replaced by element type CQDMEM.

3145 *** USER FATAL MESSAGE 3145, CØMPØNENT 0 (ØR BLANK) SPECIFIED FØR GRID PØINT ******** ØN ******** CARDS.

3146 *** USER FATAL MESSAGE 3146, NØN-ZERØ CØMPØNENT SPECIFIED FØR SCALAR PØINT ******** ØN ******** CARDS.

3147 *** USER FATAL MESSAGE 3147, ENFØRCED DISPLACEMENT ØN SPC CARDS SPECIFIED MØRE THAN ØNCE FØR THE SAME CØMPØNENT. SIL VALUE = ********.

The use of DIAG 21 in the Executive Control Deck will show the SIL (internal DØF) corresponding to the duplicated component.

3148 *** USER FATAL MESSAGE 3148, CRIGD3 (GENERAL RIGID) ELEMENT ******** IS NØT PRØPERLY DEFINED.

The six reference degrees of freedom selected for the element must together represent six independent components of motion.

3149 *** USER WARNING MESSAGE 3149, USER SPECIFIED NEIGHBØRHØØD CENTERED AT ØRIGIN NØT ALLØWED, CENTER SHIFTED TØ THE RIGHT .001.

Point of interest in the complex plan (α_{ai}, ω_{ai}), closest to which the eigenvalues will be computed, was input as (0.0, 0.0) on an EIGC bulk data continuation card. The point automatically used is (.001, 0.0).

3150 *** USER WARNING MESSAGE 3150, DESIRED NUMBER ØF EIGENVALUES ******** INVALID. SET = 1.

Number of accurate roots desired, N_{d1}, was omitted, input as zero, or negative on an EIGC bulk data continuation card. The number automatically used is 1.

3151 *** USER WARNING MESSAGE 3151, DYNAMIC MATRIX IS SINGULAR (ØCCURRENCE **) IN NEIGHBØRHØØD CENTERED AT ******** ********.

Point of interest in the complex plan (α_{ai}, ω_{ai}), closest to which the eigenvalues will be computed, was input too close to an eigenvalue on an EIGC bulk data continuation card. The point is automatically shifted by adding .02 to both the real and imaginary parts. If the dynamic matrix is still singular, the next neighborhood, if any, is searched.

3152 *** USER INFØRMATIØN MESSAGE 3152, SUBRØUTINE ALLMAT ØUTPUT EIGENVALUE **** IS NULL.

When an eigenvalue output from subroutine ALLMAT is exactly zero, the formula for computing the associated theoretical error test fails. The magnitude of the eigenvalue is considered to be 10^{-10} for use in that formula.

3153 *** USER WARNING MESSAGE 3153, ATTEMPT TØ NØRMALIZE NULL VECTØR IN SUBRØUTINE CFEER4. NØ ACTIØN TAKEN.

An eigenvector output from subroutine ALLMAT is a zero vector.

3154 *** USER WARNING MESSAGE 3154, SIZE ØF REDUCED PRØBLEM DECREMENTED ØNCE (NØW ****) DUE TØ NULL ERRØR ELEMENT.

If subroutine CFEER4 receives a reduced tridiagonal matrix having error element d_{m+1} exactly (0,0), it is impossible to compute meaningful theoretical error estimates for any of the eigenvalues. The size of the reduced problem is reduced by one, so that d_m becomes the new error element.

3155 *** USER WARNING MESSAGE 3155, REDUCED PROBLEM HAS VANISHED. NØ RØØTS FØUND.

If decrementing the size of the reduced problem (see message 3154) causes the size to become zero, the program continues to the next neighborhood, if any.

3156 *** USER WARNING MESSAGE 3156, SIZE ØF REDUCED PRØBLEM RESTØRED TØ **** BECAUSE NEXT ERRØR ELEMENT WAS ALSØ NULL. ERRØR ELEMENT SET = **** ****

This message follows message 3154. If d_m is also exactly zero (in addition to d_{m+1} being exactly zero), then the original reduced problem size is restored and d_{m+1} is set to (ε, 0) where ε = E/100 and E is the error tolerance on acceptable eigenvalues input on the EIGC bulk data card.

3157 *** USER WARNING MESSAGE 3157, FEER PRØCESS MAY HAVE CALCULATED FEWER ACCURATE MØDES **** THAN REQUESTED IN THE NEIGHBØRHØØD ØF **** ****

The desired number of eigenvalues specified in the EIGC bulk data continuation card exceeds the additional number that can be calculated by the Complex Tridiagonal Reduction (Complex FEER) method in the current neighborhood.

3158 *** USER WARNING MESSAGE 3158, NØ ADDITIØNAL MØDES CAN BE FØUND BY FEER IN THE NEIGHBØRHØØD ØF **** ****

An initial pseudo-random vector cannot be made orthogonal to the existing set of orthogonal vectors (which come from Restart and from all prior-neighborhood sets of eigensolutions).

3159 *** USER INFØRMATIØN MESSAGE 3159, ALL SØLUTIØNS HAVE BEEN FØUND.

The FEER method has solved the entire problem. Any additional neighborhoods (as specified by the presence of EIGC bulk data continuation cards) are ignored.

3160 *** USER INFØRMATION MESSAGE 3160, MINIMUM ØPEN CØRE NØT USED BY FEER ********* WØRDS (********* K BYTES).

This message indicates the amount of open core, in both bytes and words, not used by FEER.

3161 *** USER WARNING MESSAGE 3161, DESIRED NUMBER OF EIGENSØLUTIONS ***** FØR NEIGHBØRHØØD *** ØF *** CENTERED AT ******** ******** EXCEEDS THE EXISTING NUMBER *****, ALL EIGENSØLUTIØNS WILL BE SØUGHT.

The desired number of eigenvalues specified on the EIGC bulk data continuation card exceeds the size of the eigenmatrix, which is the maximum possible number of existing eigenvalues.

3162 *** USER WARNING MESSAGE 3162, ATTEMPT TØ NØRMALIZE NULL VECTØR. NØ ACTIØN TAKEN.

The general vector normalization routine (CFNØR1 or CFNØR2) has a zero vector input to it.

3163 *** USER WARNING MESSAGE 3163, ALL **** SØLUTIONS HAVE FAILED ACCURACY TEST. NØ RØØTS FØUND.

The number of eigensolutions passing the relative error test is zero. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error bounds could have been obtained by requesting DIAG 12 in the Executive Control Deck.

3164 *** USER INFØRMATIØN MESSAGE 3164, ALL **** SØLUTIØNS ARE ACCEPTABLE.

All the eigensolutions obtained in the reduced problem corresponding to the point of interest pass the relative error test. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error estimates could have been obtained by requesting DIAG 12 in the Executive Control Deck.

3165 *** USER INFØRMATIØN MESSAGE 3165, **** SØLUTIØNS HAVE BEEN ACCEPTED AND **** SØLUTIØNS HAVE BEEN REJECTED.

In each neighborhood defined by a center, some eigensolutions passed the relative error test and some did not.

3166 *** USER INFØRMATIØN MESSAGE 3166, ***** MØRE ACCURATE EIGENSØLUTIØNS THAT THE ***** REQUESTED HAVE BEEN FØUND FØR NEIGHBØRHØØD *** ØF *** CENTERED AT ******** ********. USE DIAG 12 TØ DETERMINE ERRØR ESTIMATES.

The number of eigensolutions passing the relative error test is greater than the number requested on the corresponding EIGC bulk data continuation card. The maximum allowable error for the relative error test is specified in field 7 of the EIGC bulk data card. A detailed list of the computed error estimates could have been obtained by requesting DIAG 12 in the Executive Control Deck.

3199 *** USER WARNING MESSAGE 3199, NØN-FATAL MESSAGES MAY HAVE BEEN LØST BY ATTEMPTING TØ QUEUE MØRE THAN ***** MESSAGES.

3301 *** USER FATAL MESSAGE 3301, IHEX* ELEMENT NUMBER ******** INSUFFICIENT CØRE TØ CØMPUTE ELEMENT MATRIX.

3302 *** USER FATAL MESSAGE 3302, IHEX* ELEMENT NUMBER ******** ILLEGAL GEØMETRY, text.

The type of geometry error is identified in "text". The possibilities are:

AR EXCEEDED ALFA EXCEEDED BETA EXCEEDED	Either correct the element or increase the allowable value on the PIHEX card for this element.
REVERSED NUMBERING	The element was numbered in a clockwise fashion rather than counter-clockwise as required. This would result in a left-handed element coordinate system. Correct the numbering sequence on the CIHEXi card for this element.
CØØRDINATES ØF TWØ PØINTS ARE THE SAME	The coordinates of all connections of the element must be different.

3303 *** USER FATAL MESSAGE 3303, STRESSES REQUESTED FOR SET *** WHICH CONTAINS NØ VALID ELEMENT ID-S.

The set of elements for which stresses were requested in this subcase contains only ID's for nonexistent elements.

3304 *** USER FATAL MESSAGE 3304, PLØAD3 CARD FRØM LØAD SET ******** REFERENCES MISSING ØR NØN-ISØPARAMETRIC ELEMENT ********.

3305 *** USER FATAL MESSAGE 3305, PLØAD3 CARD FRØM LØAD SET ******** HAS INVALID GRID PØINT NUMBERS FØR ELEMENT ********.

Either the element does not connect the specified grid points, or the grid points do not identify the diagonal of a face of the element.

3306 *** USER FATAL MESSAGE 3306, SINGULAR JACØBIAN MATRIX FØR ISØPARAMETRIC ELEMENT NUMBER ********.

The element is severely warped or the outer surface of the element is folded through itself. Check the connection card for this element and the coordinates of the points it connects.

4000 *** USER WARNING MESSAGE 4000, ØNE SIDE ØF ELEMENT ******** CØNNECTING FØUR PØINTS IS NØT APPRØXIMATELY PLANAR.

Check CWEDGE and CHEXA1 cards for order of grid point identification numbers, or incorrect grid point identification numbers.

4001 *** USER FATAL MESSAGE 4001, ELEMENT ******** DØES NØT HAVE CØRRECT GEØMETRY

4002 *** USER FATAL MESAGE 4002, MØDULE SSG1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXA1 cards for order of grid point identification numbers or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4003 *** USER FATAL MESSAGE 4003, AN ILLEGAL VALUE ØF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid WEDGE and HEXA1 elements must not have Poisson's Ratio equal 50 0.5.

4004 *** USER FATAL MESSAGE 4004, MØDULE SMA1 DETECTS BAD ØR REVERSED GEØMETRY FØR ELEMENT ID ********.

Check CWEDGE and CHEXA1 cards for order of grid point identification numbers, or incorrect grid point identification numbers. Subtetrahedra must have nonzero volume.

4005 *** USER FATAL MESSAGE 4005, AN ILLEGAL VALUE ØF -NU- HAS BEEN SPECIFIED UNDER MATERIAL ID ******** FØR ELEMENT ID ********.

Solid TETRA elements must not have Poisson's Ratio equal to 0.5.

4010 *** USER FATAL MESSAGE 4010, TEMPP3 BULK DATA CARD WITH SETID = ******** AND ELEMENT ID = ******** DØES NØT HAVE ASCENDING VALUES SPECIFIED FØR Z.

4011 *** USER FATAL MESSAGE 4011, ELEMENT TEMPERATURE SET ******** CØNTAINS MULTIPLE TEMPERATURE DATA SPECIFIED FØR ELEMENT ID ********.

Temperature for element is specified on more than one bulk data card.

4012 *** USER FATAL MESSAGE 4012, THERE IS NØ ELEMENT, GRID PØINT, ØR DEFAULT TEMPERATURE DATA FØR TEMPERATURE SET ******** WITH RESPECT TØ ELEMENT ********.

4013 *** USER FATAL MESSAGE 4013, PROBLEM LIMITATION OF 66 TEMPERATURE SETS HAS BEEN EXCEEDED.

4014 *** SYSTEM FATAL MESSAGE 4014, RØUTINE EDTL DETECTS BAD DATA ØN TEMPERATURE DATA BLØCK FØR SET ID = ********.

Data block GPTT should be investigated.

4015 *** SYSTEM WARNING MESSAGE 4015, ELEMENT THERMAL AND DEFØRMATIØN LØADING NØT CØMPUTED FØR ILLEGAL ELEMENT TYPE ******** IN MØDULE SSG1.

Only certain elements have algorithms for enforced deformation or thermal loading. This element type will not produce a load. Check DEFØRM and TEMPP1, TEMPP2, TEMPP3, and TEMPRB bulk data cards.

4016 *** USER FATAL MESSAGE 4016, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4017 *** USER FATAL MESSAGE 4017, THERE IS NØ TEMPERATURE DATA FØR ELEMENT ******** IN SET ********.

4018 *** USER FATAL MESSAGE 4018, A SINGULAR MATERIAL MATRIX -D- FØR ELEMENT ******** HAS BEEN DETECTED BY RØUTINE SSGKHI WHILE TRYING TØ CØMPUTE THERMAL LØADS WITH TEMPP2 CARD DATA.

The element bending load - curvature relation is at fault and cannot be inverted.

4019 *** SYSTEM FATAL MESSAGE 4019, SDR2E DETECTS INVALID TEMPERATURE DATA FØR ********.

Data block table GPTT should be investigated.

4020 *** SYSTEM FATAL MESSAGE 4020, TA1A HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4021 *** SYSTEM FATAL MESSAGE 4021, TA1B HAS PICKED UP TEMPERATURE SET ******** AND NØT THE REQUESTED SET ********.

The requested temperature set Id. for temperature dependent material properties can not be found in data block GPTT.

4022 *** USER FATAL MESSAGE 4022, TA1B FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4023 *** USER FATAL MESSAGE 4023, TA1A FINDS NØ ELEMENT, GRIDPØINT, ØR DEFAULT TEMPERATURE DATA FØR ELEMENT ID = ********.

4024 *** USER FATAL MESSAGE 4024, NØ CYJØIN CARDS WERE SUPPLIED.

4025 *** USER FATAL MESSAGE 4025, NØ SIDE 1 DATA FØUND.

4026 *** USER FATAL MESSAGE 4026, TØØ MANY SIDE 1 CARDS.

4027 *** USER FATAL MESSAGE 4027, NUMBER ØF ENTRIES IN SIDE 1 NØT EQUAL TØ NUMBER IN SIDE 2.

4028 *** USER FATAL MESSAGE 4028, THE CØDE FØR GRID PØINT, ********** DØES NØT MATCH THE CØDE FØR GRID PØINT **********.

A GRID point on SIDE 1 must be connected to a GRID point on SIDE 2 and a SCALAR point on SIDE 1 must be connected to a SCALAR point on SIDE 2.

4029 *** USER FATAL MESSAGE 4029, GRID PØINT, ********** APPEARS IN BØTH SIDE LISTS.

4030 *** USER WARNING MESSAGE 4030, CØMPØNENT *** ØF GRID PØINTS, ********** AND ********** CANNØT BE CØNNECTED.

4031 *** USER FATAL MESSAGE 4031, INSUFFICIENT CØRE = **** TØ READ DATA ØN AXIF CARD.

4032 *** USER WARNING MESSAGE 4032, NØ CØMPØNENTS ØF GRID PØINTS, ********** AND ********** WERE CØNNECTED.

4033 *** USER FATAL MESSAGE 4033, CØØRDINATE SYSTEM ID = **** AS SPECIFIED ØN AXIF CARD IS NØT PRESENT AMØNG ANY ØF CØRD1C, CØRD1S, CØRD2C, ØR CØRD2S CARD TYPES.

Cylindrical type assumed for continuing data check.

4034 *** USER FATAL MESSAGE 4034, INSUFFICIENT CØRE = **** TØ HØLD GRIDB CARD IMAGES.

4035 *** USER FATAL MESSAGE 4035, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A BDYLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4036 *** USER FATAL MESSAGE 4036, INSUFFICIENT CØRE TØ BUILD BØUNDARY LIST TABLE.

4037 *** USER FATAL MESSAGE 4037, GRID PØINT ********** IS LISTED MØRE THAN ØNCE.

4038 *** USER FATAL MESSAGE 4038, RINGFL CARD HAS ID = **** WHICH HAS BEEN USED.

An identification number of a RINGFL card is not unique.

4039 *** USER FATAL MESSAGE 4039, NØ CØØRDINATE SYSTEM DEFINED FØR GRID PØINT **********.

4040 *** USER FATAL MESSAGE 4040, ID = **** APPEARS ØN A BDYLIST CARD, BUT NØ RINGFL CARD IS PRESENT WITH THE SAME ID.

4041 *** USER FATAL MESSAGE 4041, ID = **** IS ØUT ØF PERMISSABLE RANGE ØF 1 to 499999.

The identification number of a RINGFL is too large to be processed.

4042 *** USER FATAL MESSAGE 4042, CØØRDINATE SYSTEM IS CYLINDRICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X2 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4043 *** USER FATAL MESSAGE 4043, CØØRDINATE SYSTEM IS SPHERICAL BUT RINGFL CARD ID = **** HAS A NØNZERØ X3 VALUE.

The azimuthal angle of a RINGFL point must be zero.

4044 *** USER FATAL MESSAGE 4044, RINGFL CARD ID = **** HAS SPECIFIED A ZERØ RADIAL LØCATIØN.

4045 *** USER FATAL MESSAGE 4045, THE BØUNDARY LIST ENTRY FØR ID = **** HAS A ZERØ CRØSS-SECTIØNAL LENGTH.

A hydroelastic boundary can not be defined between two RINGFL points having the same location. Check BDYLIST and RINGFL.

4047 *** USER FATAL MESSAGE 4047, INSUFFICIENT CØRE TØ HØLD RINGFL IMAGES.

4048 *** USER FATAL MESSAGE 4048, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A FSLIST CARD AND THERE IS NØ DEFAULT FLUID DENSITY SPECIFIED ØN THE AXIF CARD.

4049 *** USER FATAL MESSAGE 4049, INSUFFICIENT CØRE TØ BUILD FREE SURFACE LIST TABLE.

4050 *** USER FATAL MESSAGE 4050, FSLIST CARD HAS INSUFFICIENT IDF DATA, ØR FSLIST DATA MISSING.

A referenced RINGFL point doesn't exist or the FSLIST card is in error. At least two points must be defined.

4051 *** USER FATAL MESSAGE 4051, AN MPC CARD HAS A SET ID SPECIFIED = 102. SET 102 IS ILLEGAL WHEN FLUID DATA IS PRESENT

This set identification number is reserved for internal use in hydroelastic problems.

4052 *** USER FATAL MESSAGE 4052, IDF = **** ØN A FREEPT CARD DØES NØT APPEAR ØN ANY FSLIST CARD.

A referenced RINGFL point must also appear on a FSLIST card.

4053 *** USER FATAL MESSAGE 4053, INSUFFICIENT CØRE TØ PERFØRM ØPERATIØNS REQUIRED AS A RESULT ØF FREEPT ØR PRESPT DATA CARDS.

4054 *** USER WARNING MESSAGE 4054, STRESSES ØR FØRCES REQUESTED FØR SET(S) WHICH CØNTAIN NØ VALID ELEMENTS.

Stress or force output requests are not valid for fluid elements.

4055 *** USER FATAL MESSAGE 4055, SET ID = 102 MAY NØT BE USED FØR SPC CARDS WHEN USING THE HYDRØELASTIC-FLUID ELEMENTS.

This set identification number is reserved for internal use in hydroelastic problems.

4056 *** USER FATAL MESSAGE 4056, RECORD ID **** **** IS ØUT ØF SYNC ØN DATA BLØCK NUMBER **** AN IFP4 SYSTEM ERRØR.

The record identification numbers are the values of LØCATE record ID. The data block numbers are the GINØ file numbers. Error implies that IFP4 is possibly operating on the wrong data block. This system error should not occur. Message comes from IFP4B.

4057 *** USER FATAL MESSAGE 4057, GRIDB CARD WITH ID = **** HAS A REFERENCE IDF = **** WHICH DØES NØT APPEAR IN A BØUNDARY LIST.

4058 *** USER FATAL MESSAGE 4058, THE FLUID DENSITY HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = *** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4059 *** USER FATAL MESSAGE 4059, THE FLUID BULK MØDULUS HAS NØT BEEN SPECIFIED ØN A CFLUID CARD WITH ID = **** AND THERE IS NØ DEFAULT ØN THE AXIF CARD.

4060 *** SYSTEM FATAL MESSAGE 4060, CØØRDINATE SYSTEM = **** CAN NØT BE FØUND IN CSTM DATA.

Data blocks MATPØØL or CSTM have been changed illegally.

4061 *** SYSTEM FATAL MESSAGE 4061, CØNNECTED FLUID PØINT ID = **** IS MISSING BGPDT DATA.

Data blocks MATPØØL or BGPDT have been changed illegally.

4062 *** USER FATAL MESSAGE 4062, DMIG BULK DATA CARD SPECIFIES DATA BLØCK **** WHICH ALSØ APPEARS ØN A DMIAX CARD.

One direct input matrix may not be specified by both types of bulk data cards.

4063 *** USER FATAL MESSAGE 4063, ILLEGAL VALUE **** FØR PARAMETER CTYPE.

4064 *** USER FATAL MESSAGE 4064, ILLEGAL VALUES ******** FØR PARAMETERS NSEGS, KMAX.

4065 *** USER FATAL MESSAGE 4065, ILLEGAL VALUE ******** FØR PARAMETER NLØAD.

4066 *** USER FATAL MESSAGE 4066, SECØND ØUTPUT DATA BLØCK MUST NØT BE PURGED.

The transformation matrix between physical and symmetric components does not exist. Ensure the number of Case Control subcases is specified correctly and that the component loads are properly ordered.

4067 *** USER FATAL MESSAGE 4067, VIN HAS ******** CØLS, GCYC HAS ******** RØWS.

Follows message 4064 indicating the illegal values for NSEGS and KMAX.

4081 *** USER FATAL MESSAGE 4081, AXSLØT DATA CARD IS NØT PRESENT ØR IS INCØRRECT.

Acoustic analysis data is present and this data card is necessary.

4082 *** USER FATAL MESSAGE 4082, INSUFFICIENT CØRE TO HØLD ALL GRIDS CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4083 *** USER FATAL MESSAGE 4083, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES.

Executive Module IFP5 must hold this data in core. Increase core size or decrease amount of data.

4084 *** USER FATAL MESSAGE 4084, INSUFFICIENT CØRE TØ HØLD ALL GRIDF CARD IMAGES BEING CREATED INTERNALLY DUE TØ GRIDS CARDS SPECIFYING AN IDF.

Executive Module IFP5 is creating GRIDF cards from GRIDS cards. Increase core size.

4085 *** USER FATAL MESSAGE 4085, INSUFFICIENT CØRE TØ CØNSTRUCT ENTIRE BØUNDARY TABLE FØR SLBDY DATA CARDS.

Executive Module IFP5 requires five words of core for each entry in the SLBDY cards.

4086 *** USER FATAL MESSAGE 4086, CELAS2 DATA CARD HAS ID = XXX WHICH IS GREATER THAN 10000000, AND 10000000 IS THE LIMIT FØR CELAS2 ID WITH ACØUSTIC ANALYSIS DATA CARDS PRESENT.

Executive Module IFP5 is generating CELAS2 images and a possible conflict of ID numbers exists.

4087 *** USER FATAL MESSAGE 4087, SLBDY ID = XXX DØES NØT APPEAR ØN ANY GRIDS DATA CARD.

The SLBDY data card has a point listed which does not exist in the data.

4088 *** USER FATAL MESSAGE 4088, ØNE ØR MØRE ØF THE FØLLØWING ID-S NØT EQUAL TØ -1 HAVE INCØRRECT ØR NØ GEØMETRY DATA. ID = XXX, ID = XXX, ID = XXX.

The listed GRIDS points may have a bad radius or a slot width greater than geometrically possible.

4089 *** USER FATAL MESSAGE 4089, RHØ AS SPECIFIED ØN SLBDY ØR AXSLØT DATA CARD IS 0.0 FØR ID = XXX.

A value of density is required to formulate the slot boundary matrix terms.

4090 *** USER FATAL MESSAGE 4090, ØNE ØF THE FØLLØWING NØN-ZERØ IDENTIFICATIØN NUMBERS APPEARS ØN SØME CØMBINATIØN GRID, GRIDS, ØR GRIDF BULK DATA CARDS. ID = XXX, ID = XXX, ID = XXX.

All GRID, SPØINT, EPØINT, GRIDS, and GRIDF data cards should have unique identification numbers.

4091 *** USER FATAL MESSAGE 4091, BAD GEØMETRY ØR ZERØ CØEFFICIENT FØR SLØT ELEMENT NUMBER XXX.

The listed CSLØT3 or CSLØT4 element has its connected points defining zero area or its density equal to zero.

4100 *** SYSTEM FATAL MESSAGE 4100, ØUTPUT3 UNABLE TØ ØPEN DATA BLØCK ********.

4101 *** SYSTEM FATAL MESSAGE 4101, ØUTPUT3 UNABLE TØ FIND NAME FØR DATA BLØCK *******************.

4102 *** SYSTEM FATAL MESSAGE 4102, ØUTPUT3 EØF.

4103 *** USER INFØRMATIØN MESSAGE 4103, ØUTPUT3 HAS PUNCHED MATRIX DATA BLØCK ******** ØNTØ DMI CARDS.

4104 *** USER FATAL MESSAGE 4104, ATTEMPT TØ PUNCH MØRE THAN 9999 DMI CARDS FØR A SINGLE MATRIX.

4105 *** USER INFØRMATIØN MESSAGE 4105, DATA BLØCK ******** RETRIEVED FRØM USER TAPE **** NAME ØF DATA BLØCK WHEN PLACED ØN USER TAPE WAS ********.

4106 *** SYSTEM FATAL MESSAGE 4106, MØDULE INPUTT1 - SHØRT REC.

4107 *** SYSTEM FATAL MESSAGE 4107, SUBRØUTINE INPTT1 UNABLE TØ ØPEN NASTRAN FILE ****.

4108 *** SYSTEM FATAL MESSAGE 4108, SUBRØUTINE INPTT1 UNABLE TØ ØPEN ØUTPUT DATA BLØCK ****.

4109 *** SYSTEM FATAL MESSAGE 4109, UNEXPECTED EØF IN SUBRØUTINE INPTT1.

4110 *** SYSTEM FATAL MESSAGE 4110, UNEXPECTED EØR IN SUBRØUTINE INPTT1.

4111 *** USER FATAL MESSAGE 4111, MØDULE INPUTT1 IS UNABLE TØ SKIP FØRWARD ********** DATA BLØCKS ØN PERMANENT NASTRAN FILE **** NUMBER ØF DATA BLØCKS SKIPPED = *****.

4112 *** USER FATAL MESSAGE 4112, MØDULE INPUTT1 - ILLEGAL VALUE FØR SECØND PARAMETER = *******************.

4113 *** USER FATAL MESSAGE 4113, MØDULE INPUTT1 - ILLEGAL VALUE FØR FIRST PARAMETER = *******************.

4114 *** USER INFØRMATIØN MESSAGE 4114, DATA BLØCK ******** WRITTEN ØN NASTRAN FILE ****, TRL = ************.

4115 *** SYSTEM FATAL MESSAGE 4115, MØDULE ØUTPUT1 - SHØRT REC.

4116 *** SYSTEM FATAL MESSAGE 4116, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN INPUT DATA BLØCK *****.

4117 *** SYSTEM FATAL MESSAGE 4117, SUBRØUTINE ØUTPT1 UNABLE TØ ØPEN NASTRAN FILE ****.

6001 *** USER FATAL MESSAGE 6001, SUBSTRUCTURE DATA IS REQUIRED WITH THIS APPRØACH.

The program expects a SUBSTRUCTURE card following the CEND card if APP DISP, SUBS was used.

6002 *** USER WARNING MESSAGE 6002, INCØRRECT PHASE DATA

The second word on the substructure command should be PHASEi, i = 1, 2, 3. The default is 2.

6003 *** USER FATAL MESSAGE 6003, ILLEGAL CØMMAND ØR ØPTIØN DEFINED ØN PREVIØUS CARD.

The program does not recognize the previous card. If any "subcommand" cards follow this error, they may produce this message until a legitimate command card is encountered.

6004 *** USER WARNING MESSAGE 6004, NØ PREFIX DEFINED AFTER EQUIVALENCE CØMMAND.

A non-basic substructure requires a prefix for the equivalent lower level basic substructures. A basic substructure does not require the prefix.

6005 *** USER FATAL MESSAGE 6005, ILLEGAL ØR MISSING INPUT DATA GIVEN FØR PREVIØUS CØMMAND.

Either the basic command data is insufficient or mandatory additional subcommands are missing.

6006 *** USER FATAL MESSAGE 6006, DMAP ALTERS INTERFERE WITH SUBSTRUCTURE ALTERS.

The DMAP instruction numbers on the user ALTER data card overlaps or conflicts with the sections automatically modified. Use DIAG 23 to print the DMAP ALTER package or see Sections 5 and 3. Note also that the card APP DISPLACEMENT,SUBS,1 suppresses the automatic generation of DMAP instructions.

6007 *** SYSTEM FATAL MESSAGE 6007, IMPRØPER FILE SETUP FØR ****.

An external I/Ø operation has been defined but the file is missing or the card is improper.

6008 *** USER FATAL MESSAGE 6008, ILLEGAL INPUT ØN THE PREVIØUS CØMMAND. MISSING FILE NAME FØR I/Ø OPERATION.

6009 *** SYSTEM FATAL MESSAGE 6009, UNRECØVERABLE ERRØR CØNDITIØNS IN SUBRØUTINE ASDMAP.

6010 *** SYSTEM FATAL MESSAGE 6010, ILLEGAL VARIABLE TØ BE SET IN DMAP STATEMENT, (N).

The system has been encountered illegal type of word to be inserted in a DMAP sequence. Could possibly occur if a floating point number were used instead of an integer on an input card.

6011 *** USER FATAL MESSAGE 6011, MISSING PASSWØRD ØR SØF DATA.

The SØF and PASSWØRD cards are mandatory. At least one SØF file SØF(1) must be defined.

6012 *** SYSTEM FATAL MESSAGE 6012, FILE=**** IS PURGED ØR NULL AND IS REQUIRED IN PHASE1 SUBSTRUCTURE ANALYSIS.

6013 *** USER FATAL MESSAGE 6013, ILLEGAL TYPE ØF PØINT DEFINED FØR SUBSTRUCTURE ANALYSIS. PØINT NUMBER=*******.

6014 *** USER FATAL MESSAGE 6014, INSUFFICIENT CØRE TØ LØAD TABLES IN MØDULE SUBPH1, CØRE=********.

6015 *** USER FATAL MESSAGE 6015, TØØ MANY CHARACTERS TØ BE INSERTED IN A DMAP LINE. N=***.

A BCD word has been defined with too many characters to fit the space in the DMAP. (Usual limit = 8.) Message could also occur if block data subprogram ASDBD has an error.

6016 *** USER FATAL MESSAGE 6016, TØØ MANY DIGITS TØ BE INSERTED IN DMAP VALUE=***.

An integer is limited to eight digits.

6022 *** USER FATAL MESSAGE 6022, SUBSTRUCTURE ***, GRID PØINT ***, CØMPØNENT ***, REFERENCED ØN *** CARD DØES NØT EXIST IN SØLUTIØN STRUCTURE ***.

6023 *** USER WARNING MESSAGE 6050, REQUESTED PLØT SET NØ. ****************** HAS NØT BEEN DEFINED.

6101 *** SYSTEM FATAL MESSAGE 6101, REQUESTED SØF ITEM DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.
Either the item has never been created or it only pseudo exists from a prior dry run.

6102 *** SYSTEM FATAL MESSAGE 6102, REQUESTED SUBSTRUCTURE DØES NØT EXIST. ITEM ***, SUBSTRUCTURE ***.

6103 *** SYSTEM FATAL MESSAGE 6103, REQUESTED SØF ITEM HAS INVALID NAME. ITEM ***, SUBSTRUCTURE ***.
Item name is illegal.

6104 *** USER FATAL MESSAGE 6104, ATTEMPT TØ CREATE DUPLICATE SUBSTRUCTURE NAME ***.

6105 *** USER FATAL MESSAGE 6105, ATTEMPT TØ RE-USE SUBSTRUCTURE *** IN A REDUCE ØR CØMBINE ØPERATIØN. USE EQUIV SUBSTRUCTURE CØMMAND.
A single substructure may be reduced or combined repeatedly only if it is given equivalent names with the EQUIV substructure command.

6106 *** SYSTEM FATAL MESSAGE 6106, UNEXPECTED END ØF GRØUP ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

6107 *** SYSTEM FATAL MESSAGE 6107, UNEXPECTED END ØF ITEM ENCØUNTERED WHILE READING ITEM *** SUBSTRUCTURE ***.

6108 *** SYSTEM FATAL MESSAGE 6108, INSUFFICIENT SPACE ØN SØF FØR ITEM ***, SUBSTRUCTURE ***.

6201 *** SYSTEM INFØRMATIØN MESSAGE 6201, *** FILES HAVE BEEN ALLØCATED TØ THE SØF WHERE
SIZE ØF FILE 1 = *** BLØCKS
:
SIZE ØF FILE *** = *** BLØCKS
AND WHERE A BLØCK CØNTAINS *** WØRDS

6202 *** USER FATAL MESSAGE 6202, THE REQUESTED NUMBER ØF FILES IS NØN-PØSITIVE.

6204 *** USER FATAL MESSAGE 6204, SUBRØUTINE *** - THE SUBRØUTINE SØFØPN SHØULD BE CALLED PRIØR TØ ANY ØF THE SØF UTILITY SUBRØUTINES.

6205 *** USER FATAL MESSAGE 6205, SUBRØUTINE *** - THE BUFFER SIZE HAS BEEN MØDIFIED.

6206 *** USER FATAL MESSAGE 6206, SUBRØUTINE *** - WRØNG PASSWØRD ØN SØF FILE ***.

6207 *** USER FATAL MESSAGE 6207, SUBRØUTINE *** - THE SØF FILE *** IS ØUT ØF SEQUENCE.

6208 *** USER FATAL MESSAGE 6208, SUBRØUTINE *** - THE SIZE OF THE SØF FILE *** HAS BEEN MØDIFIED.

6209 *** USER FATAL MESSAGE 6209, SUBRØUTINE *** - THE NEW SIZE ØF FILE *** IS TØØ SMALL.

6211 *** USER WARNING MESSAGE 6211, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** HAS ALREADY BEEN WRITTEN.

6212 *** USER WARNING MESSAGE 6212, MØDULE *** - THE SUBSTRUCTURE *** DØES NØT EXIST.

6213 *** USER WARNING MESSAGE 6213, MØDULE *** - *** IS AN ILLEGAL ITEM NAME.

6215 *** USER WARNING MESSAGE 6215, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** PSEUDØ-EXISTS ØNLY.

6216 *** USER WARNING MESSAGE 6216, MØDULE *** - ITEM *** ØF SUBSTRUCTURE *** DØES NØT EXIST.

6217 *** USER WARNING MESSAGE 6217, MØDULE *** - *** IS AN ILLEGAL PARAMETER NAME.

6218 *** USER WARNING MESSAGE 6218, MØDULE *** - THE SUBSTRUCTURE *** CANNØT BE DESTRØYED BECAUSE IT IS AN IMAGE SUBSTRUCTURE.

6219 *** USER WARNING MESSAGE 6219, MØDULE *** RUN EQUALS DRY ØR STEP, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES ALREADY EXISTS.

6220 *** USER WARNING MESSAGE 6220, MØDULE *** - RUN EQUALS GØ, AND, SUBSTRUCTURE *** ØR ØNE ØF THE NEW NAMES DØES NØT EXIST.

6222 *** USER FATAL MESSAGE 6222 - ATTEMPT TØ CALL SØFØPN MØRE THAN ØNCE WITHØUT CALLING SØFCLS.

6223 *** USER FATAL MESSAGE 6223 - SUBRØUTINE *** - THERE ARE NØ MORE FREE BLØCKS AVAILABLE ØN THE SØF.

6224 *** SYSTEM FATAL MESSAGE 6224, SØF UTILITY SUBRØUTINE ***.

Text follows the message to describe the error.

6225 *** SYSTEM FATAL MESSAGE 6225, BLØCK NUMBER *** ØUT ØF RANGE ØF SØF FILES.

This means the SØF file does not contain all the data expected. Check previous jobs to verify where the intended SØF write operation may have failed, or determine if more information was expected.

6226 *** SYSTEM WARNING MESSAGE 6226, SUBRØUTINE SØFIØ - HIBLK PARAMETER FØR SØFIØ DID NØT CØNFØRM TØ PHYSICAL FILE. PARAMETER VALUE HAS BEEN CHANGED FRØM *** TØ ***.

This can be caused when the previous run using the SØF terminated abnormally. (CDC only.)

6227 *** SYSTEM FATAL MESSAGE 6227, AN ATTEMPT HAS BEEN MADE TØ ØPERATE ØN THE MATRIX ITEM *** ØF SUBSTRUCTURE *** USING SFETCH.

6228 *** USER INFØRMATIØN MESSAGE 6228, SUBSTRUCTURE *** IS ALREADY EQUIVALENT TØ SUBSTRUCTURE ***. ØNLY ITEMS NØT PREVIØUSLY EXISTING FØR *** HAVE BEEN MADE EQUIVALENT.

6229 *** USER INFØRMATIØN MESSAGE 6229, SUBSTRUCTURE *** HAS BEEN RENAMED TØ ***.

6230 *** USER WARNING MESSAGE 6230, SUBSTRUCTURE *** HAS NØT BEEN RENAMED BECAUSE *** ALREADY EXISTS ØN THE SØF.

6231 *** USER WARNING MESSAGE 6231, INSUFFICIENT CØRE AVAILABLE ØR ILLEGAL ITEM FØRMAT REQUIRES AN UNFØRMATTED DUMP TØ BE PERFØRMED FØR ITEM *** ØF SUBSTRUCTURE ***.

6232 *** SYSTEM FATAL MESSAGE 6232, ERRØR ØCCURRED WHILE INITIALIZING SØF FILE FT** *** MISSING DD CARD.

A DD statement must be included in the JCL to allocate space defined on the SØF declaration card (IBM only). See the discussion related to IBM 360/370 pertaining to the SØF declaration control in Section 2.7.

6236 *** USER WARNING MESSAGE 6236, DURING THE CREATIØN ØF A NEW IMAGE SUBSTRUCTURE NAMED ********, THE LAST CHARACTER ØF SUBSTRUCTURE NAMED ******** WAS TRUNCATED TØ MAKE RØØM FØR THE PREFIX.

If an original substructure name is eight characters long, the last character is truncated to make room for the prefix. However, if the truncated name happens to duplicate an existing name, message 6104 will result.

6301 *** SYSTEM FATAL MESSAGE 6301, DATA MISSING IN GØ MØDE FØR SUBSTRUCTURE ***, ITEM ***.

Item was created in dry run mode and has no real data.

6302 *** SYSTEM FATAL MESSAGE 6302, *** IS ILLEGAL MATRIX TYPE FØR MØDULE CØMB2.

6303 *** SYSTEM FATAL MESSAGE 6303, HØRG TRANSFØRMATION MATRIX FOR SUBSTRUCTURE *** CANNØT BE FØUND ØN SØF.

6304 *** SYSTEM FATAL MESSAGE 6304, MØDULE CØMB2 INPUT MATRIX NUMBER *** FØR SUBSTRUCTURE *** HAS INCØMPATIBLE DIMENSIØNS.

Matrix dimensions conflict with those of its H or G transformation matrix.

6305 *** SYSTEM WARNING MESSAGE 6305, RECØRD NUMBER *** ØF CASESS IS NØT A RECØVER RECØRD. IT IS A *** RECØRD.

The step parameter for module RCØVR is incorrect. It should be the CASESS record number of a recover record.

6306 *** USER WARNING MESSAGE 6306, ATTEMPT TØ RECØVER DISPLACEMENTS FØR NØN-EXISTANT SUBSTRUCTURE ***.

6307 *** USER WARNING MESSAGE 6307, WHILE ATTEMPTING TØ RECØVER DISPLACEMENTS FØR SUBSTRUCTURE ***, THE DISPLACEMENTS FØR SUBSTRUCTURE *** WERE FØUND TØ EXIST IN DRY RUN FØRM ØNLY.

Before you can recover displacements of any substructure, you must first perform an actual solution. See RUN substructure command.

6308 *** USER WARNING MESSAGE 6308, NØ SØLUTIØN AVAILABLE FRØM WHICH DISPLACEMENTS FØR SUBSTRUCTURE *** CAN BE RECØVERED. HIGHEST LEVEL SUBSTRUCTURE FØUND WAS ***.

Solve the highest level substructure found or combine it to an even higher level and solve.

6309 *** SYSTEM FATAL MESSAGE 6309, INSUFFICIENT TIME REMAINING TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE ***. (PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.)

6310 *** SYSTEM WARNING MESSAGE 6310, INSUFFICIENT SPACE ØN SØF TØ RECØVER DISPLACEMENTS ØF SUBSTRUCTURE *** FRØM THØSE ØF SUBSTRUCTURE *** WHILE PRØCESSING USER RECØVER REQUEST FØR SUBSTRUCTURE ***.

Use the SØF substructure command and increase the size of the SØF and/or add more SØF units. Alternately, use EDIT to remove unwanted data.

6311 *** SYSTEM WARNING MESSAGE 6311, SDCØMP DECØMPØSITIØN FAILED ØN KØØ MATRIX FØR SUBSTRUCTURE ***.

6312 *** USER INFØRMATIØN MESSAGE 6312, LEVEL *** DISPLACEMENTS FØR SUBSTRUCTURE *** HAVE BEEN RECØVERED AND SAVED ØN SØF.

6313 *** SYSTEM WARNING MESSAGE 6313, INSUFFICIENT CØRE FØR RCØVR MØDULE WHILE TRYING TØ PRØCESS PRINTØUT DATA BLØCKS FØR SUBSTRUCTURE ***.

6314 *** SYSTEM WARNING MESSAGE 6314, ØUTPUT REQUEST CANNØT BE HØNØRED. RCØVR MØDULE ØUTPUT DATA BLØCK *** IS PURGED.

6315 *** USER WARNING MESSAGE 6315, RCØVR MØDULE IS UNABLE TØ FIND SUBSTRUCTURE *** AMØNG THØSE ØN EQSS. LØAD SET *** FØR THAT SUBSTRUCTURE WILL BE IGNØRED IN CREATING THE SØLN ITEM FØR FINAL SØLUTIØN STRUCTURE ***.

6316 *** USER WARNING MESSAGE 6316, RCØVR MØDULE IS UNABLE TØ FIND LØAD SET *** FØR SUBSTRUCTURE *** AMØNG THØSE ØN LØDS. IT WILL BE IGNØRED IN CREATING THE SØLN ITEMS FØR FINAL SØLUTIØN STRUCTURE ***.

6317 *** SYSTEM WARNING MESSAGE 6317, RECØVER ØF DISPLACEMENTS FØR SUBSTRUCTURE *** ABØRTED.

6318 *** SYSTEM WARNING MESSAGE 6318, ØUTPUT REQUEST FØR REACTIØN FØRCES IGNØRED.

6319 *** SYSTEM WARNING MESSAGE 6319, DISPLACEMENT MATRIX FØR SUBSTRUCTURE *** MISSING. DISPLACEMENT ØUTPUT REQUESTS CANNØT BE HØNØRED AND SPCFØRCE ØUTPUT REQUESTS CANNØT BE HØNØRED UNLESS THE REACTIØNS HAVE BEEN PREVIØUSLY CØMPUTED.

6320 *** SYSTEM WARNING MESSAGE 6320, LØADC DATA MISSING FØR SUBSTRUCTURE ***, EXTERNAL STATIC LØAD SET ***.

No LØADC bulk data cards can be found on GEØM4 or GEØM4 is purged.

6321 *** USER INFØRMATIØN MESSAGE 6321, SUBSTRUCTURE PHASE 3 RECØVER FØR FINAL SØLUTIØN STRUCTURE *** AND BASIC SUBSTRUCTURE ***.

6322 *** SYSTEM FATAL MESSAGE 6322, SØLN ITEM HAS INCØRRECT RIGID FØRMAT NUMBER. PHASE 2 RIGID FØRMAT WAS *** AND PHASE 3 IS ***.

The Rigid Format of Phase 3 must be the same as that used in Phase 2 to obtain the solution.

6323 *** USER WARNING MESSAGE 6323, NØ EIGENVALUES FØR THIS SØLUTIØN.

6324 *** USER FATAL MESSAGE 6324, PHASE 3 RECØVER ATTEMPTED FØR NØN-BASIC SUBSTRUCTURE ***.

Substructure Phase 3 can be executed only for basic substructures.

6325 *** USER WARNING MESSAGE 6325, SUBSTRUCTURE PHASE 1, BASIC SUBSTRUCTURE *** ALREADY EXISTS ØN SØF. ITEMS WHICH ALREADY EXIST WILL NØT BE REGENERATED.

Use DESTRØY or EDIT to remove items which are to be regenerated.

6326 *** USER WARNING MESSAGE 6326, SUBSTRUCTURE ***, ITEM *** ALREADY EXISTS ØN SØF.

Follows message 6325, above.

6327 *** USER INFØRMATIØN MESSAGES 6327, SUBSTRUCTURE ***, SUBCASE *** IS IDENTIFIED BY *** SET *** IN LØDS ITEM. REFER TØ THIS NUMBER ØN LØADC CARDS.

6328 *** SYSTEM FATAL MESSAGE 6328, MØRE THAN 100 SUBCASES DEFINED. SGEN PRØGRAM LIMIT EXCEEDED.

To increase this limit to more than 100 subcases, change the dimensions of local arrays LØAD, MPC, and SPC in subroutine SGEN and change the IF test which causes termination.

6329 *** USER FATAL MESSAGE 6329, SUBSTRUCTURE ***, REFERENCES ØN *** CARD, IS NØT A CØMPØNENT BASIC SUBSTRUCTURE ØF SØLUTIØN STRUCTURE ***.

6330 *** USER FATAL MESSAGE 6330, SØLUTIØN SUBSTRUCTURE *** -- *** AND *** CARDS CANNØT BE USED TOGETHER. USE EITHER ØNE, BUT NØT BØTH.

6331 *** USER FATAL MESSAGE 6331, SØLUTIØN SUBSTRUCTURE *** -- LØADC SET *** REFERENCES UNDEFINED LØAD SET *** ØF BASIC SUBSTRUCTURE ***.

6332 *** SYSTEM FATAL MESSAGE 6332, CAN'T FIND LØAD VECTOR NUMBER *** IN LØAD MATRIX OF *** CØLUMNS BY *** RØWS FØR SØLUTIØN STRUCTURE ***.

6333 *** USER FATAL MESSAGE 6333, *** IS AN INVALID FØRMAT PARAMETER FØR MODULE EXIØ.

6334 *** USER WARNING MESSAGE 6334, EXIØ DEVICE PARAMETER SPECIFIES TAPE, BUT UNIT *** IS NØT A PHYSICAL TAPE.

6335 *** USER WARNING MESSAGE 6335, *** IS AN INVALID DEVICE FØR MØDULE EXIØ.

6336 *** USER INFØRMATIØN MESSAGE 6336, EXIØ FILE IDENTIFICATIØN. PASSWØRD ***. DATE ***. TIME ** ** **.

This message is caused when an I/Ø operation is requested. The data (in the form mm/dd/yy) and the time (in the form hh=mm=ss) indicate when the operation began.

6337 *** USER INFØRMATIØN MESSAGE 6337, *** BLØCKS (*** SUPERBLØCKS) ØF THE SØF SUCCESSFULLY DUMPED TØ EXTERNAL FILE ***.

6338 *** USER WARNING MESSAGE 6338, *** IS AN INVALID MØDE PARAMETER FØR MØDULE EXIØ.

6339 *** USER WARNING MESSAGE 6339, *** IS AN INVALID FILE PØSITIØNING PARAMETER FØR MØDULE EXIØ.

6340 *** USER WARNING MESSAGE 6340, SUBSTRUCTURE *** ITEM *** PSEUDØ-EXISTS ØNLY AND CANNØT BE CØPIED ØUT BY EXIØ.

6341 *** USER INFØRMATIØN MESSAGE 6341, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ *** (***, ***).

The message follows message 6336 to indicate the substructure item that was copied, the input file, and the output file. The information in parentheses is the date and time in the same form as described under message 6336.

6342 *** USER WARNING MESSAGE 6342, SØF RESTØRE ØPERATIØN FAILED. THE RESIDENT SØF IS NØT EMPTY.

Use the NEW option on the SØF substructure command to create a "new" SØF.

6343 *** SYSTEM WARNING MESSAGE 6343, *** IS NØT AN EXTERNAL SØF FILE.

Either (1) tape contained no data, (2) first record read was not an ID or header record, (3) tape was incorrectly positioned, or (4) GINØ buffer size was changed.

6344 *** USER INFØRMATIØN MESSAGE 6344, SØF RESTØRE ØF *** BLØCKS SUCCESSFULLY CØMPLETED.

6345 *** USER WARNING MESSAGE 6345, SUBSTRUCTURE *** ITEM *** IS DUPLICATED ON EXTERNAL FILE ***. ØLDER VERSIØN (***, ***) IS IGNØRED.

6346 *** USER WARNING MESSAGE 6346, SUBSTRUCTURE *** ITEM *** NØT CØPIED. IT ALREADY EXISTS ØN THE SØF.

6347 *** USER INFØRMATIØN MESSAGE 6347, SUBSTRUCTURE *** ADDED TØ THE SØF.

HIGHER LEVEL SUBSTRUCTURE ********

COMBINED SUBSTRUCTURE ********

LOWER LEVEL SUBSTRUCTURE ********

6348 *** USER WARNING MESSAGE 6348, SUBSTRUCTURE *** ITEM *** NØT FØUND ØN EXTERNAL FILE ***.

6349 *** USER INFØRMATIØN MESSAGE 6349, CØNTENTS ØF EXTERNAL SØF FILE *** FØLLØW.

6350 *** USER WARNING MESSAGE 6350, SØF APPEND ØF FILE *** FAILED. "text"

"text" explains why the append operation failed.

6351 *** USER WARNING MESSAGE 6351, DUPLICATE SUBSTRUCTURE NAME *** FØUND DURING SØF APPEND ØF FILE ***. THE SUBSTRUCTURE WITH THIS NAME ØN THE FILE BEING APPENDED WILL BE PREFIXED WITH "Q".

6352 *** USER INFØRMATIØN MESSAGE 6352, EXTERNAL SØF FILE *** SUCCESSFULLY APPENDED TØ THE RESIDENT SØF.

6353 *** USER INFØRMATIØN MESSAGE 6353, SUBSTRUCTURE *** ITEM *** HAS BEEN SUCCESSFULLY CØMPRESSED.

6354 *** USER INFØRMATIØN MESSAGE 6354, THERE ARE *** FREE BLØCKS (*** WØRDS) ØN THE RESIDENT SØF.

6355 *** SYSTEM INFØRMATIØN MESSAGE 6355, EXIØ TERMINATED WITH ERRØRS. DRY RUN MØDE ENTERED.

The parameter DRY has been set to -2 to prevent matrix operations from occurring downstream in this run.

6356 *** USER WARNING MESSAGE 6356, *** IS AN INVALID UNIT FØR MØDULE EXIØ, EXTERNAL FØRMAT.

6357 *** USER INFØRMATIØN MESSAGE 6357, SUBSTRUCTURE *** ITEM *** SUCCESSFULLY CØPIED FRØM *** TØ ***.

6359 *** USER INFORMATIØN MESSAGE 6359, SUBSTRUCTURE *** WAS ØRIGINALLY A SECØNDARY SUBSTRUCTURE. ØN THIS SØF, IT IS A PRIMARY SUBSTRUCTURE.

6361 *** USER INFØRMATIØN MESSAGE 6361, PHASE 1 SUCCESSFULLY EXECUTED FØR SUBSTRUCTURE ***.

6362 *** USER FATAL MESSAGE 6362, MPCS SET *** IS ILLEGAL. SUBSTRUCTURE *** GRID PØINT *** CØMPØNENT *** SIGNIFIES A NØN-UNIQUE DEPENDENT DEGREE ØF FREEDØM.

6365 *** USER WARNING MESSAGE 6365, REQUESTED ØUTPUT SET ID *** IS NØT DECLARED IN CASE CØNTRØL, ALL ØUTPUT WILL BE PRØDUCED.

6366 *** USER WARNING MESSAGE 6366, THE RECØVER ØUTPUT CØMMAND SØRT MUST APPEAR BEFØRE THE FIRST BASIC SUBCØMMAND. ANY ØTHER SØRT CØMMANDS ARE IGNØRED.

6367 *** USER WARNING MESSAGE 6367, ILLEGAL FØRMAT ØN THE RECØVER ØUTPUT CØMMAND ***, CØMMAND IGNØRED.

6368 *** USER WARNING MESSAGE 6368, THE SUBSTRUCTURE *** APPEARING ØN A BASIC CØMMAND IS NØT A CØMPØNENT ØF ***. ALL ØUTPUT REQUESTS UNTIL THE NEXT BASIC, PRINT, ØR SAVE ARE IGNØRED.

6501 *** USER FATAL MESSAGE 6501, THE MANUAL CØMBINE ØPTIØN HAS BEEN SPECIFIED, BUT NØ CØNNECTIØN SET WAS GIVEN.

6502 *** USER FATAL MESSAGE 6502, NØ NAME HAS BEEN SPECIFIED FØR THE RESULTANT CØMBINED PSEUDØ-STRUCTURE.

6504 *** USER FATAL MESSAGE 6504, A TØLERANCE MUST BE SPECIFIED FØR A CØMBINE ØPERATIØN.

6505 *** USER FATAL MESSAGE 6505, THE SYMMETRY ØPTIØN *** CØNTAINS AN INVALID SYMBØL.

6506 *** USER FATAL MESSAGE 6506, THE CØMPØNENT SUBSTRUCTURE *** IS NØT ØNE ØF THØSE ØN THE CØMBINE CARD.

6507 *** USER FATAL MESSAGE 6507, THE SUBSTRUCTURE *** DØES NØT EXIST ØN THE SØF.

6508 *** USER FATAL MESSAGE 6508, THE NAME SPECIFIED FØR THE RESULTANT PSEUDØSTRUCTURE ALREADY EXISTS ØN THE SØF.

6510 *** USER FATAL MESSAGE 6510, THE REQUESTED CØMBINE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

6511 *** USER FATAL MESSAGE 6511, THE REQUESTED TRANS SET ID *** HAS NØT BEEN DEFINED BY BULK DATA.

6512 *** USER FATAL MESSAGE 6512, REDUNDANT CØNNECTIØN SET ID'S HAVE BEEN SPECIFIED.

6513 *** USER FATAL MESSAGE 6513, THE TRANS SET ID *** REQUESTED BY A GTRAN BULK DATA CARD HAS NØT BEEN DEFINED.

6514 *** USER FATAL MESSAGE 6514, ERRØRS HAVE BEEN FØUND IN THE MANUALLY SPECIFIED CØNNECTIØN ENTRIES. SUMMARY FØLLØWS.

6515 *** USER FATAL MESSAGE 6515, GRID PØINT *** BASIC SUBSTRUCTURE *** DØES NØT EXIST.

6516 *** USER INFØRMATION MESSAGE 6516, ALL MANUAL CØNNECTIØNS SPECIFIED ARE ALLØWABLE WITH RESPECT TØ TØLER.

6517 *** USER FATAL MESSAGE 6517, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A RELES BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6518 *** USER FATAL MESSAGE 6518, ØNE ØF THE CØMPØNENT SUBSTRUCTURES HAS BEEN USED IN A PREVIØUS CØMBINE OR REDUCE.

Each substructure may be used in only one CØMBINE or REDUCE. The previous CØMBINE or REDUCE must be DESTRØYed before it may be used again. An alternative is to EQUIV the substructure in question to a new substructure and then use the new substructure in the desired CØMBINE operation.

6519 *** USER FATAL MESSAGE 6519, REDUNDANT NAMES FØR RESULTANT PSEUDØSTRUCTURE HAVE BEEN SPECIFIED.

6520 *** USER FATAL MESSAGE 6520, REDUNDANT VALUES FØR TØLER HAVE BEEN SPECIFIED.

6521 *** USER INFØRMATIØN MESSAGE 6521, MØDULE CØMB1 SUCCESSFULLY CØMPLETED.

6522 *** USER FATAL MESSAGE 6522, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CØNCT1 BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6523 *** USER FATAL MESSAGE 6523, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A CØNCT BULK DATA CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6524 *** USER FATAL MESSAGE 6524, NØ. ØF CØLUMNS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX B FØR A(T)B + E PRØBLEM.

6525 (1) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPY3 = ********** SECØNDS.

6525 (2) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPYAD - (AT * B)* A + E = ********** SECØNDS.

6525 (3) *** USER INFØRMATIØN MESSAGE 6525, TRIPLE MULTIPLY TIME ESTIMATE FØR MPYAD - AT * (B*A) + E = ********** SECØNDS.

6526 *** USER INFØRMATIØN MESSAGE 6526, THE CENTER MATRIX IS TØØ LARGE FØR IN-CØRE PRØCESSING. ØUT-ØF-CØRE PRØCESSING WILL BE PERFØRMED.

6528 *** USER FATAL MESSAGE 6528, INCØMPATIBLE LØCAL CØØRDINATE SYSTEMS HAVE BEEN FØUND. CØNNECTIØN ØF PØINTS IS IMPØSSIBLE, SUMMARY FØLLØWS.

6530 *** USER FATAL MESSAGE 6530, THE BASIC SUBSTRUCTURE *** REFERRED TØ BY A GTRAN CARD CANNØT BE FØUND IN THE PRØBLEM TABLE ØF CØNTENTS.

6531 *** USER FATAL MESSAGE 6531, NØ CØNNECTIØNS HAVE BEEN FØUND DURING THE AUTØMATIC CØNNECTIØN PRØCEDURE.

6532 *** USER FATAL MESSAGE 6532, THE GNEW ØPTIØN IS NØT CURRENTLY AVAILABLE.

6533 *** USER FATAL MESSAGE 6533, ØPTIØNS PA HAS BEEN SPECIFIED BUT THE LØAP ITEM ALREADY EXISTS FOR SUBSTRUCTURE ***.

6534 *** USER FATAL MESSAGE 6534, ØPTIONS PA HAS BEEN SPECIFIED BUT THE SUBSTRUCTURE *** DØES NØT EXIST.

6551 *** USER FATAL MESSAGE 6551, MATRIX B IN MPY3 IS NØT SQUARE FØR A(T)BA + E PRØBLEM.

6552 *** USER FATAL MESSAGE 6552, NØ. ØF RØWS ØF MATRIX A IN MPY3 IS UNEQUAL TØ NØ. ØF RØWS ØF MATRIX B FØR A(T)B + E PRØBLEM.

6553 *** USER FATAL MESSAGE 6553, NØ. ØF RØWS ØF MATRIX A IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX B FØR A(T)BA + E PRØBLEM.

6554 *** USER FATAL MESSAGE 6554, NØ. ØF CØLUMNS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX A FØR A(T)BA + E PRØBLEM.

6555 *** USER FATAL MESSAGE 6555, MATRIX E IN MPY3 IS NØT SQUARE FØR A(T)BA + E PRØBLEM.

6556 *** USER FATAL MESSAGE 6556, NØ. ØF RØWS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF RØWS ØF MATRIX B FØR BA + E PRØBLEM.

6557 *** USER FATAL MESSAGE 6557, UNEXPECTED NULL CØLUMN ØF A(T) ENCØUNTERED.

6558 *** USER FATAL MESSAGE 6558, INSUFFICIENT TIME REMAINING FØR MPY3 EXECUTIØN.

6559 *** USER FATAL MESSAGE 6559, NØ. ØF RØWS ØF MATRIX E IN MPY3 IS UNEQUAL TØ NØ. ØF CØLUMNS ØF MATRIX A FØR A(T)B + E PRØBLEM.

6601 *** USER FATAL MESSAGE 6601, REQUEST TØ REDUCE PSEUDØSTRUCTURE *** INVALID. DØES NØT EXIST ØN THE SØF.

6602 *** USER FATAL MESSAGE 6602, THE NAME *** CANNØT BE USED FØR THE REDUCED PSEUDØSTRUCTURE. IT ALREADY EXISTS ØN THE SØF.

6603 *** USER FATAL MESSAGE 6603, A BØUNDARY SET MUST BE SPECIFIED FØR A REDUCE ØPERATIØN.

6604 *** USER WARNING MESSAGE 6604, A BØUNDARY SET HAS BEEN SPECIFIED FØR ***, BUT IT IS NØT A CØMPØNENT ØF THE PSEUDØSTRUCTURE BEING REDUCED. THE BØUNDARY SET WILL BE IGNØRED.

6605 *** USER WARNING MESSAGE 6605, A BØUNDARY SET HAS BEEN SPECIFIED FØR *** BUT IT IS NØT A PHASE1 BASIC SUBSTRUCTURE. THE BØUNDARY SET WILL BE IGNØRED.

6606 *** USER FATAL MESSAGE 6606, BØUNDARY SET *** SPECIFIED IN CASE CØNTRØL HAS NØT BEEN DEFINED BY BULK DATA.

No BDYC bulk data has been entered.

6607 *** USER FATAL MESSAGE 6607, NØ BDYS ØR BDYS1 BULK DATA HAS BEEN INPUT TØ DEFINE BØUNDARY SET ***.

6608 *** USER FATAL MESSAGE 6608, THE REQUEST FØR BØUNDARY SET ***, SUBSTRUCTURE *** WAS NØT DEFINED.

6609 *** USER INFØRMATIØN MESSAGE 6609, NØ BØUNDARY SET HAS BEEN SPECIFIED FØR CØMPØNENT *** ØF PSEUDØSTRUCTURE ***. ALL DEGREES ØF FREEDØM WILL BE REDUCED.

6610 *** USER WARNING MESSAGE 6610, DEGREES ØF FREEDØM AT GRID PØINT *** CØMPØNENT SUBSTRUCTURE *** INCLUDED IN A BØUNDARY SET DØ NØT EXIST. REQUEST WILL BE IGNØRED.

6611 *** USER FATAL MESSAGE 6611, GRID PØINT *** SPECIFIED IN BØUNDARY SET *** FØR SUBSTRUCTURE *** DØES NØT EXIST.

6612 *** USER FATAL MESSAGE 6612, THE REDUCE ØPERATIØN REQUIRES SUBSTRUCTURE BULK DATA WHICH HAS NØT BEEN GIVEN.

6613 *** USER FATAL MESSAGE 6613, FØR RUN=GØ, THE REDUCED SUBSTRUCTURE *** MUST ALREADY EXIST.

6614 *** USER FATAL MESSAGE 6614, ILLEGAL ØR NØN-EXISTANT STRUCTURE NAME USED ABØVE.

6615 *** USER FATAL MESSAGE 6615, ILLEGAL BØUNDARY SET IDENTIFICATIØN NUMBER.

6616 *** USER INFØRMATIØN MESSAGE 6616, MØDULE REDUCE SUCCESSFULLY CØMPLETED.

6900 *** USER INFØRMATIØN MESSAGE 6900, LØADS HAVE BEEN SUCCESSFULLY APPENDED FØR SUBSTRUCTURE ***.

6901 *** USER INFØRMATIØN MESSAGE 6901, ADDITIØNAL LØADS HAVE BEEN SUCCESSFULLY MERGED FØR SUBSTRUCTURE.

6951 *** USER FATAL MESSAGE 6951, INSUFFICIENT CØRE TØ LØAD TABLES. IN MØDULE LØDAPP, CØRE = ***.

6952 *** USER FATAL MESSAGE 6952, REQUESTED SUBSTRUCTURE *** DØES NØT EXIST.

6953 *** SYSTEM FATAL MESSAGE 6953, A WRØNG CØMBINATIØN ØF LØAD VECTØRS EXISTS FØR SUBSTRUCTURE ***.

6954 *** SYSTEM FATAL MESSAGE 6954, THE **** ITEM EXISTS BUT HAS NØ ASSØCIATED PVEC ITEM FØR SUBSTRUCTURE ********.

6956 *** USER FATAL MESSAGE 6956, INSUFFICIENT TIME REMAINING FOR MODULE LØDAPP, TIME LEFT = TIME LEFT = ********.

7019 *** USER INFØRMATIØN MESSAGE 7019. MØDULE DSCHK IS EXITING FØR REASØN *** ØN ITERATIØN NUMBER ****** / PARAMETER VALUES ARE AS FØLLØWS DØNE = **********, SHIFT = **********, DSEPSI = **************.

See Section 3.5 for a discussion of Rigid Format 4 output features.

7. NASTRAN DICTIONARY

7.1 NASTRAN DICTIONARY

This section contains descriptions of mnemonics, acronyms, phrases, and other commonly used NASTRAN terms. The first column of the Dictionary contains the NASTRAN terms in alphabetical order. The second column contains a code indicating a general category for each term. The codes and categories, along with general references to the Programmer's Manual and User's Manual, are as follows:

Code	Category	General Reference
IA	Input - Executive Control	UM-2.2
IB	Input - Bulk Data	UM-2.4
IC	Input - Case Control	UM-2.3
EM	Executive Module	UM-5.7
FMH	Functional Module - Heat	PM-4
FMS	Functional Module - Structural	PM-4
FMM	Functional Module - Matrix Operation	UM-5.4
FMU	Functional Module - Utility	UM-5.5
FMX	Functional Module - User	UM-5.6
DBM	Data Block - Matrix	PM-2
DBML	Data Block - Matrix List	PM-2
DBT	Data Block - Table	PM-2
P	Parameter Name	UM-3
PU	Parameter set by user	UM-2.4
L	Rigid Format Label	UM-3
PH	Common Phrase or Term	
M	Miscellaneous	

The third column of the Dictionary contains a definition or description of the terms given in the first column. References to the User's Manual are indicated by UM-i and the Programmer's Manual by PM-i, where i is the section number of the manual. References to particular rigid formats are indicated by D-i, H-i, or A-i where i is the rigid format number in the displacement, heat, and aero approaches, respectively.

A	P	Parameter value used to control utility module MATGPR print of A-set matrices.
ABFL	DBM	$[A_{b,f\ell}]$ - Hydroelastic boundary area factor matrix.
ABFLT	DBM	Transpose of $[A_{b,f\ell}]$
ACCE	IC	Abbreviated form of ACCELERATIØN.
ACCELERATIØN	IC	Output request for acceleration vector. (UM-2.3, 4.2)
ACPT	DBT	Aerodynamic Conenction and Property Data.
Active Column	PH	Column containing at least one nonzero term outside the band.
ADD	FMM	Functional module to add two matrices together.
ADD	M	Parameter constant used in utility module PARAM.
ADD5	FMM	Functional module to add up to five matrices together.
ADR	FMS	Aerodynamic data recovery.
ADUMi	IB	Defines attributes of dummy elements 1 through 9.
AEFACT	IB	Used to input lists of real numbers for aeroelastic analysis.
AERØ	DBT	Aerodynamic Matrix Generation Data.
AERØ	IB	Gives basic aerodynamic parameters.
AERØF	IC	Aerodynamic force output request.
AJJL	DBML	Aerodynamic Influence Matrix List.
ALL	IC	Output request for all of a specified type of output.
ALLEDGE TICS	IC	Request tic marks on all edges of X-Y plot.
ALTER	IA	Alter statement for DMAP or rigid format.
ALWAYS	P	Parameter set to -1 by a PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
AMG	FMS	Aerodynamic Matrix Generator.
AMP	FMS	Aerodynamic Matrix Processor.
AND	M	Parameter constant used in executive module PARAM.
AØUT$	M	Indicates restart with solution set output request.
APD	FMS	Aerodynamic pool distributor and element generator.
APP	IA	Control card which specifies approach (DISP, DMAP, HEAT or AERØ)
APP	P	Approach flag used for modules with several functions.
APPEND	M	File may be extended (see FILE).
ASET	IB	Analysis set coordinate definition card.

ASET1	IB	Analysis set coordinate definition card.
AUTØ	IC	Requests X-Y plot of autocorrelation function.
AUTØ	DBT	Autocorrelation function table.
AXES	IC	Defines orientation of object for structure plot.
AXIC	DBT	Generated by Input File Processor 3 (IFP3) for axisymmetric conical shell problems.
AXIC	IB	Axisymmetrical conical shell definition card. When this card is present, most other bulk data cards may not be used.
AXIF	IB	Controls the formulation of a hydroelastic problem.
AXISYM$	M	Indicates restart with conical shell or hydroelastic elements.
AXISYMMETRIC	IC	Selects boundary conditions for axisymmetric shell problems or specifies the existence of hydroelastic fluid harmonics.
AXSLØT	IB	Controls the formulation of acoustic analysis problems.

B	PH	Upper semiband of matrix
B2DD	DBM	$[B^2_{dd}]$ - Partition of direct input damping matrix.
B2PP	DBM	$[B^2_{pp}]$ - Direct input damping matrix for all physical points.
B2PP	IC	Selects direct input matrices - input on DMIG bulk data cards for use in Dynamics Rigid Formats (D-7 thru D-12).
B2PP$	M	Indicates restart with change in direct input damping matrices.
BAA	DBM	$[B_{aa}]$ - Partition of damping matrix
BALL EDGE TICS	IC	Request for all edge tic marks to be plotted on lower frame of an X-Y plot.
BAR	IC	Requests structure plot for all bar elements.
BARØR	IB	Bar orientation default definition.
BBAR	PH	Lower semiband of matrix.
BDD	DBM	$[B_{dd}]$ - Damping matrix used in direct formulation of dynamics problems (D-7 thru D-9).
BDEBA	P	Parameter used to indicate equivalence of BDD and BAA.
BDPØØL	DBT	Hydroelastic boundary description table.
BDYLIST	IB	Structure-fluid hydroelastic boundary definition.
BEGIN	EM	The first DMAP statement is always BEGIN.
BEGIN BULK	IB	Control card which marks the end of the case control deck. Cards following this card are assumed to be bulk data cards.
BETA	P	Factor in integration algorithm in transient heat transfer analysis.
BFF	DBM	$[B_{ff}]$ - Partition of damping matrix.
BGG	DBM	$[B_{gg}]$ - Damping matrix generated by Structural Matrix Assembler.
BGPA	DBT	Basic Grid Point Definition Table - aerodynamics.
BGPDT	DBT	Basic grid point definition table.
BHH	DBM	$[B_{hh}]$ - Partition of damping matrix.
BKLO	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis (D-5) and Normal Modes with Differential Stiffness (D-13) Rigid Formats.
BKL1	P	Constant parameter value used in functional module SDR2 in the Buckling Analysis Rigid Format (D-5).
BLANK FRAMES	IC	Requests blank frames between structure plots (UM-4.1).
BLEFT TICS	IC	Request for left edge tic marks to be plotted on bottom frame of an X-Y plot.

BMG	GMS	Generates DMIG card images describing interconnection of fluid and structure.
BNN	DBM	$[B_{nn}]$ - Partition of damping matrix.
BØTH	IC	Bulk data echo option - Requests both unsorted and sorted printout of bulk data deck.
BØV	P	Aerodynamic parameter equal to the reference semichord divided by velocity.
BPI	IC	Bits per inch - Plot tape density must be specified on control cards in addition to this data card. The required value will vary from one installation to another.
BQG	DBM	Single-point forces of constraint for a Buckling Analysis problem (D-5).
BRIGHT TICS	IC	Request for right edge tick marks to be plotted on bottom frame for X-Y plot.
BUCKLING	IA	Selects rigid format for buckling analysis.
BUCKLING	P	Constant parameter value used in functional module READ in the Buckling Analysis Rigid Format (D-5).
BUCKLING	P	Used in printing rigid format error messages for Buckling Analysis (D-5).
Bulk Data Deck	PH	The third of the three data decks necessary to run a problem under the NASTRAN system. This deck begins after the BEGIN BULK card and ends with the ENDDATA card, and contains the data of the mathematical model. The format of each bulk data card is fixed field, 8 or 16 columns for each value.
BSHH	DBM	Total modal damping matrix - h set.

C	M	Used in parameter section of DMAP statement. Indicates that parameter is a constant.
C	PH	Symbol for active column in triangular decomposition ($\bar{C}$ used for active rows).
CAERØ1	IB	Aerodynamic panel element, doublet lattice theory.
CAERØ2	IB	Aerodynamic body element, doublet lattice theory.
CAERØ3	IB	Aerodynamic surface element, Mach box.
CAERØ4	IB	Aerodynamic macro element, strip theory.
CAERØ5	IB	Aerodynamic macro element, piston theory.
CALCØMP	IC	Request California Computer plotter.
CAMERA	IC	Selects one or both of the two cameras for the SC 4020 cathode ray tube electronic plotter. This information must usually also be given to the plotter operator on the run submittal slip which will vary from one installation to another. (UM-4)
CARDNØ	P	Parameter used to accumulate a count of all card output punched except the NASTRAN restart dictionary.
CASE	FMS	Extracts user request from CASECC for current loop in dynamics rigid formats (D-7 thru D-12).
Case Control Deck	PH	The second of the three data decks necessary to run a problem under the NASTRAN system. It contains cards which select particular data sets from the Bulk Data Deck, output request cards and titling information. Cards in this deck are free field.
CASECC	DBT	Case control data block.
CASEXX	DBT	Case control data block as modified by functional module CASE.
CASEYY	DBT	Appended case control data table.
CASEZZ	DBT	CASEYY reduced to ØFREQ list.
CAXIF2	IB	Acoustic core element connection definition card.
CAXIF3	IB	Acoustic triangular element connection definition card.
CAXIF4	IB	Acoustic quadrilateral element connection definition card.
CBAR	IB	Bar element connection definition card.
CCØNEAX	IB	Axisymmetrical conical shell element connection card.
CDAMP1	IB	Scalar damper connection definition card.
CDAMP2	IB	Scalar damper property and connection definition card.
CDAMP3	IB	Scalar damper connection definition card (connecting scalar points).
CDAMP4	IB	Scalar damper property and connection definition card (connecting scalar points).

CDUMi	IB	Defines definition card for dummy elements 1 through 9.
CEAD	FMS	Complex Eigenvalue Analysis - Displacement.
CEIF	P	Parameter used in SDR2 in Complex Eigenvalue Analysis (D-7 and D-10).
CEIGN	P	Parameter used in VDR in Complex Eigenvalue Analysis (D-7 and D-10).
CELAS1	IB	Scalar spring connection definition card.
CELAS2	IB	Scalar spring property and connection definition card.
CELAS3	IB	Scalar spring connection definition card (connecting scalar points).
CELAS4	IB	Scalar spring proerpty and connecting definition card (connecting scalar points).
CEND	IA	The last card of the Executive Control Deck.
CFLUID2	IB	Fluid core element connection definition card.
CFLUID3	IB	Fluid triangular element connection definition card.
CFLUID4	IB	Fluid quadrilateral element connection definition card.
CHBDY	IB	Boundary element connection definition card for heat transfer analysis.
Checkpoint PH	PH	The process of writing selected data blocks onto the New Problem Tape for subsequent restarts.
CHEXA1	IB	Hexahedron element connection definition card - five tetrahedra.
CHEXA2	IB	Hexahedron element connection definition card - ten tetrahedra.
CHKPNT	EM	Checkpoint module.
CHKPNT	IA	Request for checkpoint execution.
CLAMA	DBT	Complex eigenvalue output table.
CLAMAL	DBT	Appended case control data table.
CLAMAL1	DBT	CLAMAL reduced to ØFREQ list.
CLEAR	IC	Causes all parameter values used for X-Y plots to be reset to their default values except plotter and the titles (UM-4.2).
CMASS1	IB	Scalar mass connection definition card.
CMASS2	IB	Scalar mass property and connection definition card.
CMASS3	IB	Scalar mass connection definition card (connecting scalar points).
CMASS4	IB	Scalar mass property and connection definition card (connecting scalar points).
CMETHØD	IC	Complex eigenvalue analysis method selection.

CMETHØD$	M	Indicates restart with change in complex eigenvalue analysis method selection.
CMPLEV	P	Parameter used in GKAD to indicate complex eigenvalue problem.
Cold Start	PH	A NASTRAN problem initiated at its logical beginning. A cold start will never use an Old Problem Tape but it may create a New Problem Tape for subsequent restarts.
CØLØR	IC	Selects ink color for table plotters (UM-4.1).
CØND	DM	Conditional transfer.
CØNM1	IB	Structural mass element connection definition card.
CØNM2	IB	Structural mass element connection definition card.
CØNRØD	IB	Rod element property and connection definition card.
CØNRØD	IC	Requests structure plot for all CONROD elements.
CØNT	L	Continue if $[K_{00}]$ is nonsingular.
CØNTINUE	L	Exit after last loop.
CØRD1C	IB	Cylindrical coordinate system definition (by grid point ID).
CØRD1R	IB	Rectangular coordinate system definition (by grid point ID).
CØRD1S	IB	Spherical coordinate system definition (by grid point ID).
CØRD2C	IB	Cylindrical coordinate system definition (by coordinates).
CØRD2R	IB	Rectangular coordinate system definition (by coordinates).
CØRD2S	IB	Spherical coordinate system definition (by coordinates).
CØSINE	IC	Indicates cosine boundary conditions for conical shell problem.
CØUPMASS	P	Parameter used to request coupled mass.
CPBAR	P	Selects couples mass option for BAR element.
CPHID	DBM	Complex Eigenvectors - solution set.
CPHIA	DBM	Complex eigenvector matrix, A-set.
CPHIH1	DBM	PHIHL reduced tc ØFREQ list.
CPHIK	DBM	Complex eigenvector matrix, aerodynamic box points.
CPHIP	DBM	Complex Eigenvectors - physical set.
CPHIPA	DBM	Complex eigenvector matrix, PA-set.
CPHIPS	DBM	Complex eigenvector matrix, PS-set.
CPQDPLT	P	Selects coupled mass option for QDPLT element.
CPQUAD1	P	Selects coupled mass option for QUAD1 element.
CPQUAD2	P	Selects coupled mass option for QUAD2 element.

CPRØD	P	Selects coupled mass option for RØD and CØNRØD elements.
CPTRBSC	P	Selects coupled mass option for TRBSC element.
CPTRIA1	P	Selects coupled mass option for TRIA1 element.
CPTRIA2	P	Selects coupled mass option for TRIA2 element.
CPTRPLT	P	Selects coupled mass option for TRPLT element.
CPTUBE	P	Selects coupled mass option for TUBE element.
CQDMEM	IB	Quadrilateral membrane element connection definition card.
CQDMEM1	IB	Isoparametric quadrilateral membrane element connection definition card.
CQDMEM2	IB	Quadrilateral membrane element connection definition card.
CQDPLT	IB	Quadrilateral bending element connection definition card.
CQUAD1	IB	General Quadrilateral element connection definition card.
CQUAD2	IB	Homogeneous quadrilateral element connection definition card.
CRØD	IB	Rod element connection definition card.
CSHEAR	IB	Shear panel element connection definition card.
CSLØT3	IB	Triangular slot element connection definition card for acoustic analysis.
CSLØT4	IB	Quadrilateral slot element connection definition card for acoustic analysis.
CSTM	DBT	Coordinate System Transformation Matrices.
CSTMA	DBT	Coordinate System Transformation Matrices - Aerodynamics.
CTETRA	IB	Tetrahedron element connection definition card.
CTØRDRG	IB	Toroidal ring element connection card.
CTRAPRG	IB	Trapezoidal ring element connection card.
CTRBSC	IB	Basic bending triangular element connection definition card.
CTRIA1	IB	General triangular element connection definition card.
CTRIA2	IB	Homogeneous triangular element connection definition card.
CTRIARG	IB	Triangular ring element connection card.
CTRMEM	IB	Triangular membrane element connection definition card.
CTRPLT	IB	Triangular bending element connection definition card.
CTUBE	IB	Tube element connection definition card.
CTWIST	IB	Twist panel element connection definition card.
CURVLINESYMBØL	IC	Request to connect points with lines and/or to use symbols for X-Y plots.

CVISC	IB	Vixcous damper element connection definition card.
CWEDGE	IB	Wedge element connection definition card.

D	P	Parameter value used to control utility module MATGPR print of solution set matrices.
DAREA	IB	Dynamic load scale card.
Data Block	PH	Designates a set of data (matrix, table) occupying a file. A file is "allocated" to a data block and a data block is "assigned" to a file.
Data Pool File	PH	An executive file containing the OSCAR and any data blocks pooled by the Executive Segment File Allocator (XSFA) module. The contents of this file are described within the data pool dictionary (DPL).
DDR	FMX	This module is reserved for user implementation.
DDR1	FMS	Dynamic Data Recovery - Phase 1.
DDR2	FMS	Dynamic Data Recovers - Phase 2.
DDRMM	FMS	Dynamic data recovery, matrix method.
Deck	PH	1. Job Control 2. Executive Control Deck 3. Substructure Control Deck 4. Case Control Deck 5. Bulk Data Deck
DECØMØPT	P	Controls type of arithmetic used in the decomposition for frequency-response problems.
DECØMP	FMM	To decompose a square matrix into upper and lower triangular factors.
Default	PH	Many NASTRAN data items have default values supplied by the system. For example, the default value for MAXLINES is 20000.
DEFØRM	IB	Enforced element deformation definition card.
DEFØRM	IC	Enforced element deformation set selection.
DEFØRM$	M	Indicates restart with change in enforced element deformation selection.
DEFØRMATIØN	IC	Indicates subcases to be used for deformed structure plots.
DELAY	IB	Dynamic load time delay card.
Delete	IB	Delete cards from Bulk Data Deck.
DELTAPG	DBM	Incremental load vector in Piecewise Linear Analysis Rigid Format (D-6).
DELTAQG	DBM	Incremental vector of single point constraint forces in the Piecewise Linear Analysis Rigid Format (D-6).
DELTAUGV	DBM	Incremental displacement vector in the Piecewise Linear Analysis Rigid Format (D-6).
DENSITY	IC	Density of lines for SC 4020 plotter.

DENSITY	IC	Plot tape density must be specified to plotter operator on run submittal form and will vary from one installation to another (UM-4.1).
DESTRY	P	Appended AJJL parameter.
DET	IB	Eigenvalue analysis method option - determinant (see EIGR, EIGB, EIGC).
DET	P	Scaled determinant $\lvert K_{oo} \rvert$, see NDET.
DIFF	P	Parameter used in the Piecewise Linear Analysis Rigid Format (D-6).
DIFFERENTIAL STIFFNESS	IA	Selects rigid format for static analysis with differential stiffness.
DIFFSTIF	P	Parameter used in the PRTPARM module in the Differential Stiffness Rigid Format (D-4).
DIRCEAD	P	Used in printing rigid format error messages for direct complex eigenvalue analysis (D-7).
DIRECT	P	Parameter used to indicate direct formulation of dynamics problems (D-7 thru D-9).
DIRECT CØMPLEX EIGENVALUES	IA	Selects rigid format for direct complex eigenvalue analysis.
DIRECT FREQUENCY RESPØNSE	IA	Selects rigid format for direct frequency and random response.
DIRECT TRANSIENT RESPØNSE	IA	Selects rigid format for direct transient response.
DIRFRRD	P	Used in printing rigid format error messages for direct frequency response.
DIRTRD	P	Used in printing rigid format error messages for direct transient response (D-9).
DISP	IA	Displacement approach to structural analysis.
DISP	IC	Abbreviated form of DISPLACEMENT.
DISPLACEMENT	IC	Request for output of displacement vector or eigenvector. (UM-2.3, 4.2)
DIT	DBT	Direct Input Table.
DIV	P	Parameter constant used in utility module PARAM.
DLØAD	IB	Dynamics load assembly definition.
DLØAD	IC	Dynamic load set solution request.
DLØAD$	M	Indicates restart with change in dynamic load set request.
DLT	DBT	Dynamic Loads Table.
DM	DBM	[D] - Rigid body transformation matrix.

DMAP	IA	Approach option (Direct Matrix Abstraction Program).
DMAP Instruction	PH	A statement in the DMAP Language.
DMAP Language	PH	Data block-oriented language used by the NASTRAN Executive System to direct the sequence and flow of modules to be executed.
DMAP Loop	PH	A DMAP sequence to be repeated, initiated with a LABEL DMAP instruction and terminated by a REPT DMAP instruction.
DMAP Module	PH	A module called by means of a DMAP instruction.
DMAP Sequence	PH	A set of DMAP instructions.
DMI	IB	Direct Matrix Input (data block is defined and used by user).
DMIAX	IB	Direct Matrix Input - Axisymmetric, used in dynamic rigid formats (D-7 thru D-12).
DMIG	IB	Direct Matrix Input - used in dynamic rigid formats (D-7 thru D-12).
Doublet Lattice	PH	Subsonic aerodynamic theory.
DPD	FMS	Dynamic Pool Distributor.
DPH	M	Data Pool Housekeeper - Executive routine.
DPHASE	IB	Dynamic load phase lead card.
DSØ	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DS1	P	Parameter used in functional module SDR2 in the Differential Stiffness Rigid Format (D-4).
DSCØ	IC	Abbreviated form of DSCØEFFICIENT.
DSCØ$	M	Indicates restart with change in differential stiffness load factor.
DSCØEFFICIENT	IC	Selects differential stiffness factor which is input on a DSFACT card.
DSCØSET	P	Differential Stiffness coefficient set number. Used in the Differential Stiffness Rigid Format (D-13).
DSFACT	IB	Differential stiffness factor set definition card.
DSMG1	FMS	Differential Stiffness Matrix Generator - Phase 1.
DSMG2	FMS	Differential Stiffness Matrix Generator - Phase 2.
DTI	IB	Direct Table Input - means by which user may directly input any table data block.
DUMMØD1	FMX	This module is reserved for user implementation.
DUMMØD2	FMX	This module is reserved for user implementation.

DUMMØD3	FMX	This module is reserved for user implementation.
DUMMØD4	FMX	This module is reserved for user implementation.
Dummy Element	PH	Provision for user to insert additional finite element into the NASTRAN element library.
Dump	PH	Printed output of contents of all, or a portion, of main memory at some point in the problem solution.
DYNAMICS	DBT	Generated by the Input File Processor (IFP) for Real Eigenvalue, Buckling, or any of the Dynamics Rigid Formats (D-3, D-5 and D-7 thru D-12).
D1JE	DBM	Downwash factors due to extra points - real.
D2JE	DBM	Downwash factors due to extra points - complex.
D1JK	DBM	Real part of downwash matrix.
D2JK	DBM	Imaginary part of downwash matrix.

E	P	Parameter value used by MATGPR to print matrices associated with extra points.
ECHØ	IC	Output request statement for echo of bulk data.
ECPT	DBT	Element Connection and Properties Table.
ECPTNL	DBT	Nonlinear subset of the ECPT. This data block is used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNL1	DBT	Updated version of the ECPTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ECPTNLPG	P	Error flag for the Piecewise Linear Analysis Rigid Format (D-6). If all elements in a piecewise linear analysis problem are linear, this error flag is set and a DMAP exit occurs.
ECT	DBT	Element Connection Table.
ECTA	DBT	Element Connection Table - Aerodynamics.
EDT	DBT	Enforced Deformation Table - generated by Input File Processor.
EED	DPT	Eigenvalue Extraction Data table (D-3, D-5, D-7, D-10, D-11, D-12, D-13, D-15, A-10, A-11).
EIGB	IB	Real eigenvalue extraction data for buckling analysis (D-5).
EIGC	IB	Complex eigenvalue extraction data card (D-7 and D-10).
EIGP	IB	Complex eigenvalue pole definition card (D-7 and D-10).
EIGR	IB	Real eigenvalue extraction data for normal mode analysis (D-3, D-10 thru D-13, D-15, A-10).
EIGVS	P	Number of eigenvalues found by CEAD module.
ELEMENTS	IC	Used in element set definition for structure plot.
ELFØRCE	IC	Output request card for element forces. (UM-2.3, 4.2).
ELSETS	DBT	Element plot set connection tables.
ELSETSA	DBT	Data block ELSETS, extended to include generated aerodynamic elements.
ELSTRESS	IC	Request for output of element stresses. (UM-2.3, 4.2).
END	IA	END is the last statement in all DMAP sequences.
ENDALTER	IA	Last card of alter packet.
ENDDATA	IB	End if Bulk Data Deck.
EØF	PH	End-of-File.
EPØINT	IB	Extra point definition card - used in dynamics problems only.
EPSHT	P	Used in convergence tests for nonlinear heat transfer analysis.

EPSILON SUB E (ϵ_e)	PH	Error ratio computed in SSG3. $\epsilon_e = \epsilon_\ell$ if the referenced load is $\{P_\ell\}$ and $\epsilon_e = \epsilon_o$ if the referenced load is $\{P_o\}$. See page 3.2-10 for mathematical definition of ϵ_o and ϵ_ℓ.
EPT	DBT	Element Property Table - output by Input File Processor.
EQAERØ	DBT	Equivalence between external points and scalar index values - Aerodynamics
EQDYN	DBT	Equivalence of internal and external indices - dynamics.
EQEXIN	DBT	Equivalence of internal and external indices.
EQUIV	EM	Equivalence data blocks.
Equivalence	PH	Data blocks are considered equivalenced when references to their equivalent names access the same physical data file.
ERRØR1	L	Label used when rigid format errors are detected.
ERRØR2	L	Label used when rigid format errors are detected.
ERRØR3	L	Label used when rigid format errors are detected.
ERRØR4	L	Label used when rigid format errors are detected.
ERRØR5	L	Label used when rigid format errors are detected.
ERRØR6	L	Label used when rigid format errors are detected.
EST	DBT	Element Summary Table.
ESTL	DBT	Element Summary Table for Linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL	DBT	Element Summary Table for Nonlinear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
ESTNL1	DBT	Updated version of the ESTNL data block. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
EVEC	DBM	Partioning vector. D-set to A and E.
EXCEPT	IC	Forms exceptions to string of values in set declarations.
EXCLUDE	IC	Used in set definition for structure plots.
Executive	PH	1. Executive Control Deck 2. NASTRAN Executive System
Executive Control Deck	PH	The first of the three data decks necessary to run a problem under the NASTRAN system. This deck begins with the ID card and ends with the CEND card. Among other things, cards in this deck select the solution approach and rigid format to be used, limit the execution time, and control checkpointing and restart.
Executive System	PH	The Executive System initiates a NASTRAN problem solution via the Preface, allocates files to data blocks during problem solution, controls the sequence of the modules to be executed, and provides for problem restart capability.

EXIT	EM	Program termination DMAP statement.
External Sort	PH	Order of grid, scalar and extra points determined by the user's numerical order of point identification.
Extra Point	PH	A "point" which is defined on a EPØINT bulk data card. An extra point has no geometrical coordinates, defines only one degree of freedom of the model and is used only in dynamics solutions.

F	P	Parameter value used by MATGPR to print F-set matrices.
FA1	FMS	Flutter Analysis - Phase 1.
FA2	FMS	Flutter Analysis - Phase 2.
FBS	FMM	Forward and Backward Substitution.
FE	P	Parameter used by MATGPR to print out FE-set matrices.
FIAT	M	File Allocation Table. Core resident executive table where data block names, status of the data blocks (assigned to a file, purged, equivalenced, etc.) and trailer for the data blocks are stored.
FILE	IA	Term appearing on the checkpoint dictionary cards indicating the file number (internal) associated with a particular data block.
FILE	M	The FILE DMAP statement specifies data block characteristics such as TAPE, SAVE, and APPEND.
File	PH	Designates an auxiliary storage area or unit.
FIND	IC	Selects parameters for structure plot.
FINIS	L	Label used in all displacement rigid format DMAPs to terminate execution of DMAP.
Finite Element	PH	Idealized unit of a structural model that represents the distributed elastic properties of a structure.
FIST	M	File Status Table. Core resident executive table where internal file names and pointers to the FIAT, pertaining only to the module being executed, are stored.
FLAGS	IA	Term appearing on the checkpoint dictionary cards indicating the status of a data block (equivalenced or not).
FLFACT	IB	Specifies densities, Mach numbers and frequencies.
FLIST	DBT	Flutter Control Table.
FLØØP	P	Flutter loop counter/control.
FLSYM	IB	Structural symmetry definition card for use in hydroelastic problems.
FLUID	IC	Indicates hydroelastic harmonic degrees of freedom.
FLUTTER	IB	Defines flutter data.
FMETHØD	IC	Flutter Analysis Method Selection.
FMØDE	P	Mode number of first mode selected by user in modal dynamics formulations.
FØL	DBT	Frequency response output frequencies.
FØRCE	IB	Static load definition (vector).
FØRCE	IC	Request for output of element forces.
FØRCE1	IB	Static load definition (magnitude and two grid points).

FORCE2	IB	Static load definition (magnitude and four grid points).
FORCEAX	IB	Static load definition for conical shell problem.
FREEPT	IB	Defines point on a free surface of a fluid for output purposes.
FREQ	IB	Frequency list definition.
FREQ$	M	Indicates restart with change in frequencies to be solved.
FREQ1	IB	Frequency list definition (linear increments).
FREQ2	IB	Frequency list definition (logarithmic increments).
FREQRESP	P	Parameter used in SDR2 to indicate a frequency response problem.
FREQUENCY	IC	Selects the set of frequencies to be solved in frequency response problems.
FREQY	P	Selects between frequency and transient in aeroelastic response.
FRL	DBT	Frequency Response List.
FRLG	FMS	Frequency response load generator.
FRQSET	P	Used in FRRD to indicate user selected frequency set.
FRRD	FMS	Frequency and Random Response - Displacement approach.
FRRD2	FMS	Frequency response, with aerodynamic matrix capability.
FSAVE	DBT	Flutter Storage Save Table.
FSLIST	IB	Defines a free surface of a fluid in a hydroelastic problem.
Functional Module	PH	An independent group of subroutines that perform a structural analysis function.

G	P	1. Parameter used by MATGPR to print G-set matrices. 2. Parameter used to input uniform structural damping coefficient (D-7 thru D-9).
GEI	DBT	General Element Input.
GENEL	IB	General element definition.
GEØM1	DBT	Geometric data input table - generated by the Input File Processor.
GEØM2	DBT	Connection input table - generated by the Input File Processor.
GEØM3	DBT	Static load and temperature input table - generated by the Input File Processor.
GEØM4	DBT	Displacement sets definition input table - generated by the Input File Processor.
GI	FMS	Geometry Interpolator.
GINØ	M	General input/output. GINØ is a collection of subroutines which is the input/output control system for NASTRAN.
GINØ Buffer	PH	Storage reserved in open core for each GINØ file opened. The size of the buffer is machine dependent.
GINØ File Number	PH	File number used internally in DMAP modules to access data blocks.
GIV	IB	Eigenvalue analysis method option - Givens (see EIGR).
GKAD	FMS	General [K] Assembler - Direct.
GKAM	FMS	General [K] Assembler - Modal.
GM	DBM	$[G_m]$ - multipoint constraint transformation matrix.
GMD	DBM	$[G_m^d]$ - mulitpoint constraint transformation matrix used in dynamic analysis.
GNFIAT	M	Generate FIAT. The preface routine which generates the initial FIAT.
GØ	DBM	$[G_o]$ - structural matrix partitioning transformation matrix.
GØD	DBM	$[G_o^d]$ - Structural matrix partitioning transformation matrix used in dynamic analysis.
GP1	FMS	Geometry Processor - part 1.
GP2	FMS	Geometry Processor - part 2.
GP3	FMS	Geometry Processor - part 3.
GP4	FMS	Geometry Processor - part 4.
GPCT	DBT	Grid Point Connection Table.
GPDT	DBT	Grid Point Definition Table.
GPI	M	General Problem Initialization (see XGPI).
GPL	DBT	Grid Point List.

GPLA	DBT	Grid Point List - Aerodynamics.
GPLD	DBT	Grid Point List used in dynamic analysis.
GPSETS	DBT	Grid point plot sets.
GPSETSA	DBT	Data block GPSETS, extended to include generated aerodynamic grid points.
GPSP	FMS	Grid Point Singularity Processor.
GPST	DBT	Grid Point Singularity Table.
GPTT	DBT	Grid Point Temperature Table.
GPWG	FMS	Grid Point Weight Generator.
GRAV	IB	Gravity vector definition card.
GRDPNT	P	Used in all displacement rigid formats to specify execution of the grid point weight generator (GPWG) by the user. A positive value references a grid point of the structural model. A value of zero indicates the origin of the basic coordinate system.
GRDSET	IB	Grid point default definition card.
GRID	IB	Grid point definition card.
Grid Point	PH	A point in Euclidean 3-dimensional space defined on a GRID bulk data card. A grid point defines 6 degrees of freedom, 3 translational and 3 rotational.
GRID PØINTS	IC	Used in set definition for structure plots.
GRIDB	IB	Grid point definition card for hydroelastic model.
GRIDF	IB	Grid point definition card for axisymmetric fluid cavity.
GRIDS	IB	Grid point definition card for slotted acoustic cavity.
GTKA	DBM	Aerodynamic transformation matrix - k-set to a-set.
GUST	FMS	Calculates loads due to gust.
GUST	IB	Defines stationary vertical gust.
GUST	IC	Aerodynamic gust input request.
GUSTAERØ	PU	Requests matrices used only in gust calculations to be computed.

HARMONICS	IC	Controls number of harmonics output in axisymmetric shell problems and hydroelastic problems.
HB2DD	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HB2PP	DBM	$[B^2_{dd}]$ - Partition of heat capacity matrix.
HBAA	DBM	$[B_{aa}]$ - Partition of heat capabity matrix.
HBDD	DBM	$[B_{dd}]$ - Partition of heat capacity matrix.
HBFF	DBM	$[B_{ff}]$ - Partition of heat capacity matrix.
HBGG	DBM	$[B_{gg}]$ - Heat capacity matrix.
HBNN	DBM	$[B_{nn}]$ - Partition of heat capacity matrix.
HDLT	DBT	Dynamic loads table for heat transfer analysis.
Header record	PH	Initial record of a data block. Typically a header record contains only 2 BCD words, the alphanumeric name of the data block.
HEAT	IA	Selects heat transfer analysis on APProach card.
HFREQ	P	High frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
HK2DD	DBM	$[K^2_{dd}]$ - Partition of heat conductivity matrix.
HK2PP	DBM	$[K^2_{pp}]$ - Partition of heat conductivity matrix.
HKAA	DBM	$[K_{aa}]$ - Partition of heat conductivity matrix.
HKDD	DBM	$[K_{dd}]$ - Partition of heat conductivity matrix.
HKFF	DBM	$[K_{ff}]$ - Partition of heat conductivity matrix.
HKFS	DBM	$[K_{fs}]$ - Partition of heat conductivity matrix.
HKGG	DBM	$[K_{gg}]$ - Heat conductivity matrix, including estimated linear component of radiation.
HKGGX	DBM	$[K^x_{gg}]$ - Heat conductivity matrix.
HKNN	DBM	$[K_{nn}]$ - Partition of heat conductivity matrix.
HØEF1X	DBT	Heat flux output table for CHBDY elements.
HPDØ	DBM	$\{P^o_d\}$ - Partition of dynamic load vector.
HPDT	DBM	$\{P^t_d\}$ - Partition of dynamic load vector.
HPPØ	DBM	$\{P^o_p\}$ - Partition of dynamic load vector.
HPSØ	DBM	$\{P^o_s\}$ - Partition of dynamic load vector.
HQGE	DBM	$[Q_{ge}]$ - Element radiation flux matrix for heat transfer analysis.
HRAA	DBM	$[R_{aa}]$ - Partition of radiation matrix.
HRDD	DBM	$[R_{dd}]$ - Partition of radiation matrix.

HRFF	DBM	$[R_{ff}]$ - Partition of radiation matrix.
HRGG	DBM	$[R_{gg}]$ - Radiation matrix for heat transfer analysis.
HRNN	DBM	$[R_{nn}]$ - Partition of radiation matrix.
HSLT	DBT	Static heat flux table.
HTØL	DBT	List of output time steps for heat transfer.

IC	IC	Transient analysis initial condition set selection.
ID	IA	The first card of any data deck is the identification (ID) card. The two data items on this card are BCD values.
IFP	EM	Input File Processor. The preface module which processes the sorted Bulk Data Deck and outputs various data blocks depending on the card types present in the Bulk Data Deck.
IFP1	EM	Input File Processor 1. The preface module which processes the Case Control Deck and writes the CASECC, PCDB and XYCDB data blocks.
IFP3	EM	Input File Processor 3. The preface module which processes bulk data cards for a conical shell problem.
IFP4	EM	Input File Processor 4. The preface module which processes bulk data cards for a hydroelastic problem.
IFT	FMS	Inverse Fourier transformation.
IFTSKP	L	Used to skip IFT module.
IMAG	IC	Output request for real and imaginary parts of some quantity such as displacement, load, single point force of constraint element force, or stress.
IMPL	P	Parameter constant used in executive module PARAM.
INCLUDE	IC	Used in set definition for structure plots.
INERTIA	P	Used in printing rigid format error messages for Static Analysis with Inertia Relief (D-2).
INERTIA RELIEF	IA	Selects rigid format for static analysis with inertia relief.
INPT	M	A reserved NASTRAN physical file which must be set up by the user when used.
INPUT	FMU	Generates most of bulk data for selected academic problems.
Input Data Block	PH	A data block input to a module. An input data block must have been previously output from some module and may not be written on.
Input Data Cards	PH	The card input data to the NASTRAN system are in 3 sets, the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck.
INPUTT1	FMU	Reads data blocks from GINØ-written user tapes.
INPUTT2	FMU	Reads data blocks from FØRTRAN-written user tapes.
INPUTT3	FMX	Dummy user input module.
INPUTT4	FMX	Dummy user input module.
Internal Sort	PH	Same order as external sort except when SEQGP or SEQEP bulk data cards are used to change the sequence.
INV	IB	Inverse power eigenvalue analysis option - spevidied on EIGR, EIGB or EIGC cards.
IRES	P	Causes printout of residual vectors in statics rigid formats when set nonnegative via a PARAM bulk data card. (D-1, D-2, D-4, D-5, D-6).

JUMP	EM	Unconditional transfer DMAP statement.
JUMPPLØT	P	Parameter used by structure plotter modules PLTSET and PLOT.

K2DD	DBM	$[K^2_{dd}]$ - Partition of direct input stiffness matrix.
K2DPP	DBM	$[K^{2d}_{pp}]$ - Direct input stiffness matrix for all physical points from bulk data deck.
K2PP	DBM	$[K^2_{pp}]$ - Direct input stiffness matrix for all physical points.
K2PP	IC	Direct input stiffness matrix selection.
K2PP$	M	Indicates restart with change in direct input stiffness matrices.
K2XPP	DBM	$[K^{2x}_{pp}]$ - Direct input stiffness matrix excluding hydroelastic boundary stiffness matrix.
K4AA	DBM	$[K^4_{aa}]$ - Partition of structural damping matrix.
K4FF	DBM	$[K^4_{ff}]$ - Partition of structural damping matrix.
K4GG	DBM	$[K^4_{gg}]$ - Structural damping matrix generated by Structural Matrix Assembler.
K4NN	DBM	$[K^4_{nn}]$ - Partition of structural damping matrix.
KAA	DBM	$[K_{aa}]$ - A-set stiffness matrix.
KAAB	DBM	$[\bar{K}_{aa}]$ - Partition of stiffness matrix.
KBFS	DBM	$[K^b_{fs}]$ - Partition of combination of elastic stiffness matrix matrix and differential stiffness matrix.
KBFL	DBM	$[K_{b,f\ell}]$ - Hydroelastic boundary stiffness matrix.
KBLL	DBM	$[K^b_{\ell\ell}]$ - Combination of elastic stiffness and differential stiffness used in static analysis with differential stiffness.
KBSS	DBM	$[K^b_{ss}]$ - Partition of combination of stiffness matrix and differential stiffness matrix.
KDAA	DBM	$[K^d_{aa}]$ - Partition of differential stiffness matrix.
KDAAM	DBM	$-[K^d_{aa}]$ - Differential stiffness matrix used in formulation of buckling problems (D-5).
KDAMP	PU	-1 for structural damping, +1 for viscous.
KDD	DBM	$[K_{dd}]$ - Stiffness matrix used in direct formulation of dynamics problems (D-7 thru D-9).
KDEK2	P	Parameter indicating equavalence of KDD and K2DD.
KDEKA	P	Parameter indicating equavalence of KDD and KAA.
KDFF	DBM	$[K^d_{ff}]$ - Partition of differential stiffness matrix.
KDFS	DBM	$[K^d_{fs}]$ - Partition of differential stiffness matrix.
KDGG	DBM	$[K^d_{gg}]$ - Differential stiffness matrix prepared by Differential Stiffness Matrix Generator.
KDNN	DBM	$[K^d_{nn}]$ - Partition of differential stiffness matrix.

KDSS	DBM	$[K^d_{ss}]$ - Partition of differential stiffness matrix.
KE	PH	Flutter analysis method.
KEF	DBM	$[K_{ff}]$ - Partition of stiffness matrix.
KFS	DBM	$[K_{fs}]$ - Partition of stiffness matrix.
KGG	DBM	$[K_{gg}]$ - Stiffness matrix generated by Structural Matrix Assembler.
KGGL	DBM	$[K^{\ell}_{gg}]$ - Stiffness matrix for linear elements. Used only in the Piecewise Linear Analysis Rigid Format (D-6).
KGGLPG	P	Purge flag for KGGL matrix. If set to -1, it implies that there are no linear elements in the structural model. (D-6).
KGGNL	DBM	$[K^{n\ell}_{gg}]$ - Stiffness matrix for the nonlinear elements. Used in the Piecewise Linear Analysis Rigid Format only.
KGGSUM	DBM	Sum of KGGNL and KGGL. Used in the Piecewise Linear Analysis Rigid Format only. (D-6).
KGGX	DBM	$[K^x_{gg}]$ - Stiffness matrix excluding general elements.
KGGXL	DBM	$[K^{x\ell}_{gg}]$ - Stiffness matrix for linear elements (excluding general elements). Used in the Piecewise Linear Rigid Format only. (D-6).
KGGY	DBM	$[K^y_{gg}]$ - Stiffness matrix of general elements.
KHH	DBM	$[K_{hh}]$ - Stiffness matrix used in modal formulation of dynamics problems (D-10 thru D-12).
KLL	DBM	$[K_{\ell\ell}]$ - Stiffness matrix used in solution of problems in static analysis (D-1, D-2, D-4, D-5, D-6).
KLR	DBM	$[K_{\ell r}]$ - Partition of stiffness matrix.
KNN	DBM	$[K_{nn}]$ - Partition of stiffness matrix.
KØA	DBM	$[K_{oa}]$ - Stiffness matrix partition.
KØØ	DBM	$[K_{oo}]$ - Partition of stiffness matrix.
KRR	DBM	$[K_{rr}]$ - Partition of stiffness matrix.
KSS	DBM	$[K_{ss}]$ - Partition of stiffness matrix.
KXHH	DBM	Total modal stiffness matrix - h-set.

L	P	Parameter value used by MATGPR to print L-set matrices.
LABEL	EM	DMAP location.
LABEL	IC	Defines third line of titles to be printed on each page of printer output. Also used on plots.
LABEL	IC	Requests identification of grid points and/or elements on structure plot.
LAMA	DBT	Real eigenvalues.
LBLi	L	A label used in displacement approach rigid formats where i represents one or more characters used to form unique labels.
LBLL	DBM	$[L^b_{\ell\ell}]$ - Lower triangular factor of $[K^b_{\ell\ell}]$.
LEFT TICS	IC	Request for tic marks to be plotted on left hand edge of frame for X-Y plots.
LFREQ	P	Low frequency limit for modal formulation of dynamics problems (D-10 thru D-12).
LGPWG	L	Label used in conjunction with the Grid Point Weight Generator.
LINE	IC	Number of data lines printed per page of printer output. It should be set to 50 for 11 x 17 inch paper, and to 35 for 8 1/2 x 17 inch paper.
LLL	DBM	$[L_{\ell\ell}]$ - Lower triangular factor of $[K_{\ell\ell}]$.
LMØDES	P	Number of lowest modes for modal formulation of dynamics problems (D-10 thru D-12).
LØAD	IB	Static load combination definition.
LØAD	IC	Static load set selection.
LØAD$	M	Indicates restart with change in static load set request.
LØGARITHMIC	IC	Requests logarithmic scales for X-Y plots.
LØGPAPER	IC	Requests logarithmic paper for X-Y plots.
LØØ	DBM	$[L_{oo}]$ - Lower triangular factor of $[K_{oo}]$.
LØØP1$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPBGN	L	Signifies the beginning of the Piecewise Linear Analysis Rigid Format DMAP Loop. (D-6).
LØØPEND	L	Signifies the end of the Piecewise Linear Analysis Rigid Format DMAP loop. (D-6).
LØØP$	M	Indicates looping problem in modified restart. (PM-4.3.7.1)
LØØPTØP	L	Top of rigid format loop
LØWER TICKS	IC	Request for tic marks to be plotted on bottom edge of frame for X-Y plots.
LSING	L	Used if $[K_{oo}]$ is singular.

LUSET	P	Order of USET.
LUSETA	P	Number of degrees of freedom in the pa displacement set.
LUSETD	P	Order of USETD.

M	P	Parameter value used by MATGPR to print M-set matrices.
M2DD	DBM	$[M^2_{dd}]$ - Partition of direct input mass matrix.
M2DPP	DBM	$[M^{2d}_{pp}]$ - Direct input mass matrix for all physical points from Bulk Data Deck.
M2PP	DBM	$[M^2_{pp}]$ - Direct input massmatrix for all physical points.
M2PP	IC	Direct input mass matrix selection.
M2PP$	M	Indicates restart with change in direct input mass matrices.
MAA	DBM	$[M_{aa}]$ - Partition of mass matrix.
MACH	PU	Velocity divided by speed of sound.
MASS	IB	Eigenvector normalization option - used on EIGR card.
MAT1	IB	Material definition card for isotropic material.
MAT2	IB	Material definition card for anisotropic material.
MAT3	IB	Material definition card for orthotropic material.
MAT4	IB	Thermal material definition card for isotropic material.
MAT5	IB	Thermal material definition card for anisotropic material.
MATGPR	FMU	Utility module for printing matrices.
MATPØØL	DBT	Grid point oriented direct input matrix data pool, output by Input File Processor and used by functional module MTRXIN.
MATPRN	FMU	Utility module for printing matrices.
MATPRT	FMU	Utility module for printing matrices.
Matrix Control Block	PH	A seven word array, the first word is a GINØ file number, and words 2 through 7 comprise a matrix trailer.
Matrix Data Block	PH	A data block is classified as a matrix if and only if it is generated by one of the NASTRAN matrix packing routines, PACK or BLDPK.
Matrix Decomposition	PH	A factorization of a matrix K so that K = LU where L is a unit lower triangular matrix and U is an upper triangular matrix.
MATS1	IB	Specifies table references for stress-dependent material properties.
MATT1	IB	Specifies table references for temperature-dependent isotropic material properties.
MATT2	IB	Specifies table references for temperature-dependent anisotropic material properties.
MATT3	IB	Specifies table references for temperature-dependent orthotropic material properties.
MATT4	IB	Specifies table references for temperature-dependent isotropic, thermal material properties.

MATT5	IB	Specifies table references for temperature-dependent, anisotropic, thermal material properties.
MAX	IB	Eigenvector normalization option - used on EIGR, EIGB and EIGC cards.
MAXIMUM DEFØRMATIØN	IC	Indicates scale for deformed structure plots.
MAXIT	P	Limits maximum number of iterations in nonlinear heat transfer analysis.
MAXLINES	IC	Maximum printer output line count - default value is 20000.
MCE1	FMS	Multipoint Constraint Eliminator - part 1.
MCE2	FMS	Multipoint Constraint Eliminator - part 2.
MDD	DBM	$[M_{dd}]$ - Mass matrix used in direct formulation of dynamics problems (D-7 thru D-9).
MDEMA	P	Parameter indicating equivalence of MDD and MAA.
MDLCEAD	P	Used in printing rigid format error messages for modal complex eigenvalue analysis (D-10).
MDLFRRD	P	Used in printing rigid format error messages for modal frequency response (D-11).
MDLTRD	P	Used in printing rigid format error messages for modal transient response (D-12).
MEF1	DBT	Modal element forces, Sort 1 for ØFP.
MEF2	DBT	Modal element forces, Sort 2 for ØFP.
MERGE	FMM	Matrix merge functional module.
MES1	DBT	Modal element stresses, Sort 1 for ØFP.
MES2	DBT	Modal element stresses, Sort 2 for ØFP.
METHØD	IC	Selects method for real eigenvalue analysis.
METHØDS	M	Indicates restart with change in eigenvalue extraction procedures.
MFF	DBM	$[M_{ff}]$ - Partition of mass matrix.
MGG	DBM	$[M_{gg}]$ - Mass matrix generated by Structural Matrix Assembler.
MHH	DBM	$[M_{hh}]$ - Mass matrix used in modal formulation of dynamics problems (D-10 thru D-12).
MI	DBM	$[m]$ - Modal mass matrix.
MIND	P	Minimum diagonal term of $[U_{oo}]$.
MKAERØ1	IB	Provides table of Mach numbers and reduced frequencies (k).
MKAERØ2	IB	Provides list of Mach numbers (m) and reduced frequencies (k).

MLL	DBM	$[M_{\ell\ell}]$ - Partition of mass matrix.
MLR	DBM	$[M_{\ell r}]$ - Partition of mass matrix.
MNN	DBM	$[M_{nn}]$ - Partition of mass matrix.
MØA	DBM	$[\bar{M}_{oa}]$ - Partition of mass matrix.
MØDA	FMX	This module is reserved for user implementation.
MØDACC	FMS	Mode Acceleration Output Reduction Module.
MØDAL	IC	Requests structure plots of mode shapes.
MØDAL	P	Indicates modal as opposed to direct formulation of dynamics
MØDAL CØMPLEX EIGENVALUES	IA	Selects rigid format for modal complex eigenvalue analysis.
MØDAL FREQUENCY RESPØNSE	IA	Selects rigid format for modal frequency and random response.
MØDAL TRANSIENT RESPØNSE	IA	Selects rigid format for modal transient response.
MØDB	FMX	This module is reserved for user implementation.
MØDC	FMX	This module is reserved for user implementation.
MØDEL	IC	Indicates model number of structure plotter.
MØDES	IA	Selects rigid format for normal mode analysis.
MØDES	IC	Duplicates output requests for eigenvalue problems.
MØDES	P	Used in printing rigid format error messages for normal modes analysis (D-3).
Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution by changing the rigid format and/or selected input data.
Module	PH	A logical group of subroutines which performs a defined function.
MØMAX	IB	Conical shell moment definition card.
MØMENT	IB	Static moment load definition (vector).
MØMENT1	IB	Static moment load definition (magnitude and two grid points).
MØMENT2	IB	Static moment load definition (magnitude and four grid points).
MØØ	DBM	$[M_{oo}]$ - Partition of mass matrix.
MPC	IB	Multipoint constraint definition.
MPC	IC	Multipoint constraint set request.
MPC$	M	Indicates restart with change in multipoint constraints.
MPCADD	IB	Multipoint constraint set definition.
MPCAX	IB	Conical shell multipoint constraint definition.
MPCF1	P	No multipoint constraints.

MPCF2	P	No change in multipoint constraints for loop.
MPHIPA1	DBT	Eigenvectors, PA-set, sort 1.
MPHIPA2	DBT	Eigenvectors, PA-set, sort 2.
MPL	PH	Module properties list. The MPL defines each DMAP module's name, the number of input, output and scratch files required and the parameter list. It is used by the preface module SGPI to generate the ØSCAR.
MPT	DBT	Material Properties Table - output by Input File Processor.
MPY	M	Parameter constant used in executive module PARAM.
MPYAD	FMM	Performs multiply-add matrix operation.
MQP1	DBT	Constraint forces, PA-set, sort 1.
MQP2	DBT	Constraint forces, PA-set, sort 2.
MR	DBM	$[m_r]$ - Rigid body mass matrix.
MRR	DBM	$[M_{rr}]$ - Partition of mass matrix.
MTRXIN	FMS	Selects direct input matrices for current loop in dynamics problems (D-7 thru D-12).
MX	IC	Indicates negative x-axis direction for structure plot.
MXHH	DBM	Total modal mass matrix - h-set.
MY	IC	Indicates negative y-axis direction for structure plot.
MZ	IC	Indicates negative z-axis direction for structure plot.

N	M	Used in parameter section of DMAP statement. Indicates that parameter may not be given an initial value with a PARAM bulk data card.
N	P	Parameter value used by MATGPR to print N-set matrices.
NASTPLT	IC	Requests NASTRAN general purpose plotter.
NASTRAN	M	Acronym for NAsa STRuctural ANalysis program.
NASTRAN Data Deck	PH	The composite deck consisting of the Executive Control Deck, the Case Control Deck, and the Bulk Data Deck. This deck, when preceeded by any necessary operating system control cards, constitutes the complete card input for a NASTRAN run (PM-5).
NDET	P	Power of 10 used to scale parameter DET.
NE	P	Parameter value used by MATGPR to print out NE-set matrices.
NEIGV	P	Number of real eigenvalues found.
NEVER	P	Set to +1 by a DMAP PARAM statement in the Piecewise Linear Analysis Rigid Format (D-6).
New Problem Tape	PH	See Problem Tape.
NJ	P	Number of degrees of freedom in the j displacement set.
NK	P	Number of degrees of freedom in the k displacement set.
NLFT	DBT	Nonlinear function table.
NLLØAD	IC	Requests nonlinear load output for transient problems.
NØ	IA	Option used on CHKPNT card, indicates that no checkpoint is desired.
NØA	P	Indicates no constraints applied to structural model.
NØABFL	P	No fluid-structure interface in a hydroelastic problem.
NØB2PP	P	No direct input damping matrix.
NØBGG	P	No viscous damping matrix (D-7 thru D-9).
NØCEAD	P	Used to skip CEAD module when not required.
NØCSTM	P	No Coordinate System Transformation Matrices.
NØD	P	No output request that is limited to independent degrees of freedom.
NØDJE	PU	Positive value selects D1JE and D2JE from INPUTT2.
NØDLT	P	No Dynamic Loads Table.
NØEED	P	No Eigenvalue Extraction Data.
NØELMT	P	No elements are defined.
NØFL	P	No fluid-structure interface and no fluid gravity in a hydroelastic problem.

NØFRL	P	No Frequency Response List.
NØFRY	P	Used by aeroelastic response for transient solution.
NØGENEL	P	No general elements.
NØGPDT	P	No Grid Point Definition Table.
NØGPST	P	No grid point singularity table.
NØGRAV	P	No gravity loads.
NØGUST	P	No gust input.
NØH	L	Used to skip modal output.
NØH	P	Used to skip modal output.
NØK2PP	P	No direct input stiffness matrices.
NØK4GG	P	No structural damping matrix.
NØKBFL	P	No fluid gravity or structural interface in a hydroelastic problem.
NØL	P	No independent degrees of freedom.
NØLIN1	IB	Nonlinear transient dynamic load set definition card.
NØLIN2	IB	Nonlinear transient dynamic load set definition card.
NØLIN3	IB	Nonlinear transient dynamic load set definition card.
NØLIN4	IB	Nonlinear transient dynamic load set definition card.
NØLØØP$	M	Indicates restart of problem without DMAP loop. (PM-4.3.7.1).
NØM2DPP	P	No direct input mass matrix from Bulk Data Deck.
NØM2PP	P	No direct input mass matrices.
NØMGG	P	If functional module SMA2 generates a zero mass matrix, NOMGG is set to -1. Otherwise, it is set to +1.
NØMØD	P	Mode acceleration data recovery not requested.
NØNCUP	P	Indicates diagonal MHH, BHH, and KHH allowing uncoupled solution in TRD and FRRD.
NØNE	IC	Override for output and bulk data deck echo requests.
NØNLIFT	P	No nonlinear function table.
NØNLINEAR	IC	Selects nonlinear load for transient problems.
NØNLSTR	P	No stress output request for nonlinear elements (D-6).
NØP	M	Parameter constant used in executive module PARAM.
NØP	P	No output request involving dependent degrees of freedom or stresses.

NØPF	L	Skip load calculations in transient aeroelastic response.
NØPSDL	P	No Power Spectral Density List.
NØRMAL MØDES	IA	Selects rigid format for normal mode analysis.
NØRN	P	No random requests.
NØSET	P	No dependent coordinates.
NØSIMP	P	No structural elements are defined.
NØSØRT2	P	No request for output sorted by point number or element number.
NØSR	P	No single-point constraints or free body supports.
NØT	M	Parameter constant used in utility module PARAM.
NØTFL	P	No Transfer Function List.
NØTRL	P	No Transient Response List.
NØUE	P	No extra points introduced for dynamic analysis.
NØUE1	L	No extra points.
NØXYCBD	P	-1 indicates no XY output requests.
NØXYØUT	L	No XY-output requests.
NØXYPL	P	No XY-plot requests.
NØXYPLTT	L	No XY-plot requests.
NPLALIM	P	Set by module PLA1 as the Piecewise Linear Analysis Rigid Format DMAP loop counter. (D-6)
NPTP	M	New Problem Tape - a reserved NASTRAN physical file which must be set up by the user when used.
NSIL	P	Order of SIL table.
NSIL1	P	Number of grid and scalar points.
NSKIP	P	Locate current boundary conditions in Case Control.
NUMF	M	New User Master File - used only when operating NASTRAN as a user master file editor. (See UMFEDIT). A reserved NASTRAN physical file which must be set up by the user when used.
NVECTS	P	Number of eigenvectors found.

Ø	P	Parameter value used by MATGPR to print Ø-set matrices.
ØBEF1	DBT	Element force output table (D-5).
ØBES1	DBT	Element stress output table (D-5).
ØBQG1	DBT	Forces of single point constraint output table (D-5).
ØCEIGS	DBT	Complex eigenvalue summary table (D-7, D-10).
ØCPHIP	DBT	Complex eigenvector output table (D-7, D-10).
ØCPHIPA	DBT	Complex eigenvector output table, aeroelastic.
ØEF1	DBT	Element force output table (D-1, D-2, D-4, D-5, D-6).
ØEF2	DBT	Element force output table - SØRT2 (D-9, D-12).
ØEFB1	DBT	Element force output table (D-4).
ØEFC1	DBT	Element force output table - complex (D-7, D-8, D-10, D-11).
ØEFC2	DBT	Element force output table - complex - SØRT2 (D-8, D-11).
ØEIGS	DBT	Real Eigenvalue summary output table (D-3, D-5).
ØES1	DBT	Element stress output table (D-1, D-2, D-4, D-5, D-6).
ØES2	DBT	Element stress output table - SØRT2 (D-9, D-12).
ØESB1	DBT	Element stress output table (D-4).
ØESC1	DBT	Element stress output table - complex (D-7, D-8, D-10, D-11).
ØESC2	DBT	Element stress output table - complex - SØRT2 (D-8, D-11).
ØFP	FMS	Output File Processor.
ØFREQ	IC	Output Frequency set.
ØFREQUENCY	IC	Selects from the solution set of frequencies a subset for output requests.
ØGPST	DBT	Grid point singularity output table.
ØGPWG	DBT	Grid point weight generator output table.
Old Problem Tape	PH	See Problem Tape.
ØLØAD	IC	Request for output of external load vector.
ØMIT	IB	Omitted coordinate definition card.
ØMIT	P	Indicates no omitted coordinates.
ØMIT1	IB	Omitted coordinate definition card.
ØMITAX	IB	Omitted coordinate definition card for conical shell problems.
ØNLES	DBT	Output table for nonlinear element stresses (D-6).
Open Core	PH	A contiguous block of working storage defined by a labeled common block, whose length is a variable determined by the NASTRAN executive routine CØRSZ.
ØPG1	DBT	Static load output table (D-1, D-2, D-4, D-5, D-6).

ØPHID	DBT	Output table for complex eigenvectors - solution set (D-7).
ØPHIG	DBT	Eigenvector output table (D-3, D-5).
ØPHIH	DBT	Output table for complex eigenvectors - solution set (D-10).
ØPNL1	DBT	Output table for nonlinear loads - solution set, SØRT1 (D-9, D-12).
ØPNL2	DBT	Output table for nonlinear loads - solution set, SØRT2 (D-9, D-12).
ØPP1	DBT	Dynamic load output table (D-9, D-12).
ØPP1	DBT	Aerodynamic transient load output table, sort 1.
ØPP2	DBT	Dynamic load output table - SØRT2 (D-9, D-12).
ØPPC1	DBT	Dynamic load output table - SØRT1, complex (D-8, D-11).
ØPPC2	DBT	Dynamic load output table - SØRT2, complex (D-8, D-11).
ØPTP	M	Old Problem Tape - a reserved NASTRAN physical file which must be set up by the user when used.
ØQBG1	DBT	Forces of single-point constraint output table (D-4).
ØQG1	DBT	Single-point constraint force output table (D-1, D-2, D-4, D-5, D-6).
ØQP1	DBT	Single-point constraint force output table SØRT1 (D-9, D-12).
ØQP2	DBT	Single-point constraint force output table SØRT2 (D-9, D-12).
ØQPC1	DBT	Single-point constraint force output table - complex, SØRT1 (D-7, D-8, D-10, D-11).
ØQPC2	DBT	Single-point constraint force output table - complex, SØRT2 (D-7, D-8, D-10, D-11).
ØQPCA1	DBT	Complex constraint force output table, aeroelastic.
ØR	M	Parameter constant used in executive module PARAM.
ØRIGIN	IC	Locates origin for structure plot.
ØRTHØGRAPHIC	IC	Specifies orthographic projection for structure plot.
ØSCAR	PH	Operation sequence control array. Executive table residing on the Data Pool File which contains the sequence of operations to be executed for a problem solution. The ØSCAR is an expansion of a DMAP sequence, either input by the user or extracted from a rigid format, in internal format.
ØTIME	IC	Time selection for output.
ØUBGV1	DBT	Displacement vector output table (D-4).
ØUDV1	DBT	Displacement vector output table - solution set, SØRT1 (D-9).
ØUDV2	DBT	Displacement vector output table - solution set, SØRT2 (D-9).
ØUDVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-8, D-11).

ØUDVC2	DBT	Displacement vector output table - solution set, SØRT2, complex (D-8, D-11).
ØUGV1	DBT	Displacement output table (D-1, D-2, D-4, D-5, D-6).
ØUHV1	DBT	Displacement vector output table - solution set, SØRT1 (D-12).
ØUHV2	DBT	Displacement vector output table - solution set, SØRT2 (D-12).
ØUHVC1	DBT	Displacement vector output table - solution set, SØRT1, complex (D-11).
ØUHVC2	DBT	Displacement vector output table - solution set, SØRT2 complex (D-11).
ØUPV1	DBT	Displacement vector output table - SØRT1 (D-9, D-12).
ØUPV2	DBT	Displacement vector output table - SØRT2 (D-9, D-12).
ØUPVC1	DBT	Displacement vector output table - complex, SØRT1 (D-8, D-11).
ØUPVC2	DBT	Displacement vector output table - complex, SØRT2 (D-8, D-11).
ØUTPUT	FMX	This module is reserved for user implementation.
ØUTPUT	IC	Marks beginning of printer output request packet - optional.
Output Data Block	PH	A data block output from a module. A data block may be output from one and only one module. Having been output, it may be used as an input data block as many times as necessary.
ØUTPUT1	FMU	Writes data blocks on GINØ-written user tapes.
ØUTPUT2	FMU	Writes data blocks on FØRTRAN-written user tapes.
ØUTPUT3	FMU	Punches matrices on DMI cards.
ØUTPUT4	FMX	Dummy user output module.
ØUTPUT(PLØT)	IC	Marks beginning of output request packet for structure plots.
ØUTPUT(XYØUT)	IC	Marks beginning of output request packet for X-Y plots.
ØUTPUT(XYPLØT)	IC	Marks beginning of output request packet for X-Y plots.
ØVG	DBT	Output aeroelastic curve requests (V-g or V-f).

P	P	Parameter value used in MATGPR to print P-set matrices.
P	PH	Flutter analysis method.
Packed Format	PH	A matrix is said to be in packed format if only the nonzero elements of the matrix are written.
PAERØ1	IB	Associated bodies for Doublet Lattice panels.
PAERØ2	IB	Properties of aerodynamic bodies.
PAERØ3	IB	Defines Mach Box geometries.
PAERØ4	IB	Properties of strips (strip theory).
PAERØ5	IB	Properties of strips (piston theory).
PAPER SIZE	IC	Selects paper size for structure plots using table plotters.
PARAM	FMU	Performs specified operations on DMAP parameters.
PARAM	IB	Parameter definition card.
Parameter	PH	A FØRTRAN variable communicated to a DMAP module by the NASTRAN Executive System through blank common. A parameter's position in the DMAP calling sequence to a module corresponds to the position of the parameter in blank common at module execution time.
PARAML	FMU	Selects parameters from a user input matrix or table.
PARAMR	FMU	Performs specified operations on real or complex parameters.
PARTN	FMM	Matrix partitioning functional module.
PBAR	IB	Bar property definition card.
PBL	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PBS	DBM	A scalar multiple of the PL load vector. Used only in the Differential Stiffness Rigid Format (D-4).
PCDB	DBT	Plot control data block (table for use with structure plotter functional module PLTSET).
PCØNEAX	IB	Conical shell element property definition card.
PCPHIPA	DBT	Complex displacement plot file.
PDAMP	IB	Scalar damper property definition card.
PDF	DBM	Dynamic load matrix for frequency analysis.
PDT	DBM	Linear dynamic load matrix for transient analysis.
PDUMi	IB	Property definition card for dummy elements 1 through 9.
PELAS	IB	Scalar elastic property definition card.
PEN	IC	Selects pen size for structure plots using table plotters.
PENSIZE	IC	Selects pen size for X-Y plots using table plotters.

PERSPECTIVE	IC	Specifies perspective projection for structure plots.
PFILE	P	Parameter used by PLØT module.
PG	DBM	Incremental load vector used in Piecewise Linear Analysis (D-6).
PG	DBM	Statics load vector generated by SSG1.
PG1	DBM	Static load vector for Piecewise Linear Analysis (D-6).
PGG	DBM	Appended static load vector (D-1, D-2).
PGV1	DBM	Matrix of successive sums of incremental load vectors used only in Piecewise Linear Analysis Rigid Format (D-6).
PHASE	IC	Requests magnitude and phase form of complex quantities.
PHBDY	IB	Boundary element property definition card for heat transfer analysis.
PHF	DBM	Total frequency response loads, modal.
PHFI	DBM	Non-gust frequency response loads, modal.
PHIA	DBM	$[\phi_a]$ - Real eigenvectors - solution set.
PHIAH	DBM	Eigenvectors, A-set.
PHID	DBM	$[\phi_a]$ - Complex eigenvectors - solution set, direct formulation.
PHIDH	DBM	$[\phi_{dh}]$ - Transformation matrix between modal and physical coordinates.
PHIG	DBM	$[\phi_g]$ - Real eigenvectors.
PHIH	DBM	$[\phi_h]$ - Complex eigenvectors - solution set, modal formulation
PHIHL	DBM	Appended complex mode shapes - h-set.
PHIK	DBM	Eigenvectors, aerodynamic box points.
PHIP	DBM	Eigenvectors, P-set.
PHIPA	DBM	Eigenvectors, PA-set.
PHIPS	DBM	Eigenvectors, PS-set.
Physical Points	PH	Grid points and extra scalar points introduced for dynamic analysis.
PIECEWISE LINEAR	IA	Selects rigid format for piecewise linear analysis.
Pivot Point	PH	The first word of each record of the GPCT and ECPT data blocks is called the pivot point.
PJUMP	P	Used to skip deformed plots.
PK	PH	Flutter analysis method.
PKF	DBML	Forces on aerodynamic boxes, as a function of frequency.

PL	DBM	$\{P_\ell\}$ - Partition of load vector.
PLA	P	Used in printing rigid format error messages for Piecewise Linear Analysis (D-6).
PLA1	FMS	Piecewise Linear Analysis - phase 1.
PLA2	FMS	Piecewise Linear Analysis - phase 2.
PLA3	FMS	Piecewise Linear Analysis - phase 3.
PLA4	FMS	Piecewise Linear Analysis - phase 4.
PLACØUNT	P	Loop counter in Piecewise Linear Analysis (D-6).
PLALBL2A	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL3	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLALBL4	L	Used in the Piecewise Linear Analysis Rigid Format only. (D-6)
PLCØEFFICIENT	IC	Selects the coefficient set for Piecewise Linear Analysis problems.
PLFACT	IB	Piecewise Linear Analysis factor definition card.
PLI	DBM	$\{P^i_\ell\}$ - Partition of inertia relief load vector.
PLØAD	IB	Pressure load definition (D-1, D-2, D-4, D-5, D-6).
PLØAD2	IB	Element pressure loading for two-dimensional elements (D-1, D-2, D-4, D-5, D-6).
PLØT	FMS	Structure plot generator.
PLØT	IC	Execution card for structure plotter.
PLØT$	M	Indicates restart with a structure plot request.
Plot Tapes	PH	Magnetic tapes containing NASTRAN generated data to drive offline plotters. PLT1 is the name of the BCD plot tape and PLT2 is the name of binary plot tape.
PLØTEL	IB	Plot element definition card used to define convenient reference lines in structure plots.
PLØTTER	IC	Used to select one of several available plotters for structure plotter.
PLØTX1	DBT	Messages from plot module concerning action taken by the structure plotter in processing undeformed structure plots.
PLØTX2	DBT	Messages from plot module concerning action taken by the structure plotter in processing deformed structure plots.
PLØTX3	DBT	Deformed plot messages for aeroelastic.
PLSETNØ	P	Set number on a PLFACT bulk data card chosen by the user in his case control deck. Used only in Piecewise Linear Analysis (D-6).

PLT1	M	A reserved NASTRAN physical file which must be set up by the user when used - see Plot Tapes.
PLT2	M	A reserved NASTRAN physical file which must be set up by the user when used - see Plot Tapes.
PLTFLG	P	Parameter used by PLØT module.
PLTPAR	DBT	Plot control table.
PLTPARA	DBT	Plot control table PLTPAR, with aeroelastic data.
PLTSET	FMS	Plot set definition processor.
PLTSETA	DBT	Set definitions for aerodynamic plots.
PLTSETX	DBT	Error messages for plot sets.
PLTTRAN	FMS	Prepares data blocks for acoustic analysis plots.
PLTTRAN	FMS	Transforms grid point definition tables for scalar points into a format for plotting.
PMASS	IB	Scalar mass property definition card.
PNLD	DBM	$\{P_d^n\}$ - Nonlinear loads in direct transient problem.
PNLH	DBM	$\{P_h^n\}$ - Nonlinear loads in modal transient problem.
PØ	DBM	$\{P_o\}$ - Partition of load vector.
PØI	DBM	$\{P_o^i\}$ - Partition of inertia relief load vector.
PØINT	IB	Eigenvalue analysis normalization option for eigenvectors - see EIGR, EIGC, EIGB cards.
PØINTAX	IB	Conical shell point used for data recovery.
PØØL	M	Pool file used by file allocator.
PØUT$	M	Indicates restart with a printer output request.
PPF	DBM	Dynamic loads for frequency response.
PPHIG	DBM	Eigenvector components used to plot deformed shape. (D-3, D-5).
PPT	DBM	Linear dynamic loads for transient analysis.
PQDMEM	IB	Quadrilateral membrane element property definition card.
PQDMEM1	IB	Isoparametric quadrilateral membrane element property definition card.
PQDMEM2	IB	Quadrilateral membrane element property definition card.
PQDPLT	IB	Quadrilateral bending element property definition card.
PQUAD1	IB	General quadrilateral element property definition card.
PQUAD2	IB	Homogeneous quadrilateral element property definition card.

PREC	P	Precision of computer IBM = 2 UNIVAC CDC = 1
Preface	PH	Executive routines which are executed prior to the execution of the first module in a DMAP sequence. The Preface consists of the executive routines necessary to generate initial NASTRAN operational data and tables. The primary Preface routines are GNFIAT, XCSA, IFP1, XSØRT, IFP, IFP3, and XGPI.
PRESAX	IB	Defines static pressure loading for the conical shell element.
PRESPT	IB	Defines a point in a hydroelastic model for output purposes.
PRESSURE	IC	Request for output of pressure and displacement vector or eigenvector for a hydroelastic problem.
PRINT	PU	Controls printing of flutter summary.
Problem Tape	PH	A magnetic tape containing data necessary for NASTRAN problem restarts. A tape being generated is designated as the New Problem Tape (NPTP) and its content is largely controlled by the DMAP instruction CHKPNT. This same tape when used as input to a subsequent NASTRAN restart is designated as the Old Problem Tape (ØPTP).
PRØD	IB	Rod property definiton card.
PRØJECTIØN PLANE SEPARATIØN	IC	Separation of observer and projection plane for structure plots.
PRTMSG	FMS	Message generator.
PRTPARM	FMU	Prints DMAP diagnostic messages and parameter values.
PS	DBM	$\{P_s\}$ - Partition of static load vector.
PSDF	DBM	Power Spectral Density Function table.
PSDF	IC	Request for output of Power Spectral Density Function in Random Analysis (D-9, D-11).
PSDL	DBT	Power Spectral Density List.
Pseudo Modified Restart	PH	Restarting (see Restart) a NASTRAN problem and redirecting its solution but only affecting output data.
PSF	DBM	Partition of load vector for transient analysis.
PSHEAR	IB	Shear panel property definition card.
PST	DBM	Partition of linear load vector for transient analysis.
PTØRDRG	IB	Toroidal ring property definition card.
PRTBSC	IB	Basic bending triangular element property definition card.
PTRIA1	IB	General triangular element property definition card.
PTRIA2	IB	Homogeneous triangular element property definition card.
PTRMEM	IB	Triangular membrane element property definition card.

PTRPLT	IB	Triangular bending element property definition card.
PTUBE	IB	Tube property definition card.
PTWIST	IB	Twist panel property definition card.
PUBGV1	DBT	Displacement vector components used to plot deformed shape (D-4, D-5).
PUGV	DBT	Displacement vector components used to plot deformed shape (D-1, D-2).
PUGV1	DBT	Displacement components used to plot deformed shape (D-6).
PUNCH	IC	Output media request (PRINT or PUNCH).
PURGE	EM	DMAP statement which causes conditional purging of data blocks.
Purge	PH	A data block is said to be purged when it is flagged in the FIAT so that it will not be allocated to a physical file and so that modules attempting to access it will be signaled.
PUVPAT	DBT	Displacement vector used for plots, PA-set for aeroelastic.
PVISC	IB	Viscous element property definition card.
PVT	PH	Parameter value table. The PVT contains BCD names and values of all parameters input by means of PARAM bulk data cards. It is generated by the preface module IFP and is written on the Problem Tape.
P1	PU	INPUTT2 rewind option.
P2	PU	INPUTT2 unit number.
P3	PU	INPUTT2 tape ID.

QBDY1	IB	Defines uniform heat flux into HBDY elements.
QBDY2	IB	Defines grid point heat flux into HBDY elements.
QBG	DBM	Single point forces of constraint in the Differential Stiffness Rigid Format (D-4).
QDMEM	IC	Requests structure plot for all QDMEM elements.
QDMEM1	IC	Requests structure plot for all QDMEM1 elements.
QDMEM2	IC	Requests structure plot for all QDMEM2 elements.
QDPLT	IC	Requests structure plot for all QDPLT elements.
QG	DBM	Constraint forces for all grid points.
QHBDY	IB	Defines thermal load for steady-state heat conduction.
QHHL	DBML	Aerodynamic matrix list - h-set.
QHJL	DBML	Aerodynamic matrix for gust calculations.
QJHL	DBML	Aerodynamic transformation matrix between h and j sets.
QKHL	DBML	Aerodynamic matrix for aerodynamic force data recovery.
QP	DBM	Constraint forces for all physical points.
QPA	DBM	Constraint forces, PA-set.
QPAC	DBM	Constraint forces, complex, PA-set.
QPC	DBM	Complex single point forces of constraint for all physical points.
QPP2	DBT	Aerodynamic transient load output, sort 2.
QR	DBM	$\{q_r\}$ - Determinant support forces.
QS	DBM	$\{q_s\}$ - Single-point constraint forces.
QUAD1	IC	Requests structure plot for all QUAD1 elements.
QUAD2	IC	Requests structure plot for all QUAD2 elements.
QVECT	IB	Defines thermal vector flux from distant source.
QVØL	IB	Defines volume heat generation.

R	P	Parameter value used by MATGPR to print R-set matrices.
R1	IC	Request for X-Y plot of the first rotational component (UM-4.2).
R1IP	IC	Request for X-Y plot of the first rotational component - imaginary and phase angle (UM-4.2).
R1RM	IC	Request for X-Y plot of the first rotational component - real and magnitude (UM-4.2).
R2	IC	Request for X-Y plot of the second rotational component (UM-4.2).
R2IP	IC	Request for X-Y plot of the second rotational component - imaginary and phase angle (UM-4.2).
R2RM	IC	Request for X-Y plot of the second rotational component - real and magnitude (UM-4.2).
R3	IC	Request for X-Y plot of the third rotational component (UM-4.2).
R3IP	IC	Request for X-Y plot of the third rotational component - imaginary and phase angle (UM-4.2).
R3RM	IC	Request for X-Y plot of the third rotational component - real and magnitude (UM-4.2).
RADLIN	P	Controls linearization of radiation effects in transient heat transfer analysis.
RADLST	IB	List of radiation areas.
RADMTX	IB	Radiation exchange coefficients.
RANDØM	IC	Selects the RANDPS and RANDT cards to be used in random analysis.
RANDØM	FMS	Random response solution generator.
RANDPS	IB	Power spectral density specification.
RANDT1	IB	Autocorrelation function time lag.
RANDT2	IB	Autocorrelation function time lag.
RBMG1	FMS	Rigid body matrix generator - part 1.
RBMG2	FMS	Rigid body matrix generator - part 2.
RBMG3	FMS	Rigid body matrix generator - part 3.
RBMG4	FMS	Rigid body matrix generator - part 4.
REACT	P	Flag for rigid body mode calculations.
READ	FMS	Real Eigenvalue Analysis - Displacement.
REAL	IC	Requests real and imaginary form of complex quantities.
REAL EIGENVALUES	IA	Selects rigid format for normal mode analysis.
REEL	IA	Term appearing on the checkpoint dictionary cards indicating the physical reel on which a data block appears.

Reentry Point	PH	The point in the DMAP sequence at which a problem terminated and hence the point at which it can be restarted (see Restart).
REGIØN	IC	Specifies portion of frame to be used for structure plot.
REIG	P	Parameter used in SDR2 to indicate Normal Mode Analysis (D-3).
REPCASE	IC	Allows another output request for the previous subcase (D-1, D-2).
REPEAT	P	Controls looping in Static Analysis (D-1, D-2).
REPEATD	P	Controls looping in Static Analysis with Differential Stiffness (D-4).
REPEATE	P	Controls looping in Complex Eigenvalue Analysis (D-7, D-10).
REPEATF	P	Controls looping in Frequency Response Analysis (D-8, D-11).
REPEATT	P	Controls looping in Transient Response Analysis (D-9, D-12).
REPT	EM	DMAP statement to conditionally repeat a loop.
RESPØNSE	IC	Request for X-Y plot of any response outputs from transient or frequency response analysis (D-8, D-9, D-11, D-12).
RESTART	IA	First control card of checkpoint dictionary. Contains identification of checkpoint tape.
Restart	PH	Initiating a NASTRAN problem solution at a place other than its logical beginning by utilizing an Old Problem Tape created during a previous run.
RFØRCE	IB	Rotational force definition card.
RFØRCE$	M	Indicates restart with change in rotational force.
RG	DBM	Multipoint constraint equations.
RIGHT TICS	IC	Request for tic marks to be plotter on right hand edge of frame for X-Y plots.
Rigid Format	PH	A fixed prestored DMAP sequence and its associated restart tables which perform a specific problem solution.
Rigid Format Switch	PH	A type of restart (see Restart) in which the problem is changed from one Rigid Format to another.
RINGAX	IB	Conical shell ring definition card.
RINGFL	IB	Hydroelastic axisymmetric point definition card.
RLØAD1	IB	Frequency response load set definition.
RLØAD2	IB	Frequency response load set definition.
RMG	FMH	Radiation matrix generator - generates $[R_{gg}]$.
RØD	IC	Requests structure plot for all RØD elements.
RP	DBM	Partitioning vector set D to A and E.
RUBLV	DBM	Residual vector - Differential Stiffness Rigid Format (D-4).

RULV	DBM	Residual vector for independent degrees of fredom.
RUØV	DBM	Residual vector for omitted degrees of freedom.
RXY	IC	Requests vector sum of X and Y deformation components for structure plot.
RXYZ	IC	Requests vector sum of X, Y and Z deformation components for structure plot.
RXZ	IC	Requests vector sum of X and Z deformation components for structure plot.
RYZ	IC	Requests vector sum of Y and Z deformation components for structure plot.

S	P	Parameter value used by MATGPR to print S-set matrices.
SACCE	IC	Abbrecivated form of SACCELERATIØN.
SACCELERATIØN	IC	Output request for solution set acceleration vector. (UM-2.3, 4.2)
SAVE	EM	DMAP statement which causes current value of parameter to be saved.
SAVE	M	Save data block for possible looping in DMAP sequence (see FILE).
SC	IC	Selects SC 4020 plotter.
Scalar Point	PH	A point which is defined on an SPØINT, CELAS1, CELAS2, CELAS3, CELAS4, CMASS1, CMASS2, CMASS3, CMASS4, CDAMP1, CDAMP2, CDAMP3, or CDAMP4 bulk data card. A scalar point has no geometrical coordinates and defines only one degree of freedom of the model.
SCALE	IC	Selects scale for structure plot.
SCE1	FMS	Single-point Constraint Eliminator.
SDAMP	IC	Modal structural damping table selection.
SDAMP$	M	Indicates restart with change in modal damping.
SDAMPING	IC	Selects table which defines damping as a function of frequency in modal formulation problems.
SDISP	IC	Abbreviated form of SDISPLACEMENT.
SDISPLACEMENT	IC	Output request for solution set displacement vector. (UM-2.3, 4.2)
SDR1	FMS	Stress Data Recovery - part 1.
SDR2	FMS	Stress Data Recovery - part 2.
SDR3	FMS	Stress Data Recovery - part 3.
SDRHT	FMH	Heat flux data recovery.
SECTAX	IB	Defines conical shell sector for data recovery.
SEEMAT	FMU	Prints pictorial representation of matrix showing location of nonzero elements.
SEM1	M	The NASTRAN Preface.
SEQEP	IB	Extra point resequencing.
SEQGP	IB	Grid or scalar point resequencing.
SET	IC	Definition of a set of elements, grid and/or scalar and/or extra points, frequencies, or times to be used in selecting output.
SET1	IB	Defines a set of structural grid points by a list.
SET2	IB	Defines a set of structural grid points by aerodynamic macro elements.
SETVAL	FMU	Parameter value initiator.
SHEAR	IC	Requests structure plot for all shear panel elements.

SIGMA	P	Defines Stefan-Boltzmann constant in heat transfer analysis.
SIL	DBT	Scalar Index List for all grid points.
SILA	DBT	Scalar Index List - Aerodynamics.
SILD	DBT	Scalar Index List for all grid points and extra scalar points introduced for dynamic analysis.
SILGA	DBT	Scalar Index List - Aerodynamic boxes only.
SINE	IC	Conical shell request for sine set boundary conditions.
SING	P	-1 if $[K_{oo}]$ is singular.
SINGLE	P	No single-point constraints.
SKIP BETWEEN FRAMES	IC	Request to insert blank frames on SC 4020 plotter for X-Y plots.
SKJ	DBM	Integration matrix.
SKPMGG	P	Parameter used in statics to control execution of functional module SMA2.
SKPPLT	L	Used to skip plot.
SLBDY	IB	Defines list of points on interface between axisymmetric fluid and radial slots.
SLØAD	IB	Scalar point load definition.
SLT	DBT	Static Loads Table.
SMA1	FMS	Structural Matrix Assembler - phase 1 - generates stiffness matrix $[K_{gg}]$ and structural damping matrix $[K^4_{gg}]$.
SMA2	FMS	Structural Matrix Assembler - phase 2 - generates mass matrix $[M_{gg}]$ and viscous damping matrix $[B_{gg}]$.
SMA3	FMS	Structural Matrix Assembler - phase 3 - add general element contributions to the stiffness matrix $[K_{gg}]$.
SMP1	FMS	Structural Matrix Partitioner - part 1.
SMP2	FMS	Structural Matrix Partitioner - part 2.
SMPYAD	FMM	Performs multiply-add matrix operation for up to five multiplications and one addition.
SØL	IA	Specifies which rigid format solution is to be used when APP is DISPLACEMENT.
Solution Points	PH	Points used in the formulation of the general K system.
SØLVE	FMM	Solves a set of linear algebraic equations.
SØRT1	IC	Output is sorted by frequency or time and then by external ID.
SØRT2	IC	Output is sorted by external ID and then by frequency or time.
SØRT3	M	Output is sorted by individual item or component and then by frequency or time.
SPC	IB	Single-point constraint and enforced deformation definition.

SPC	IC	Single-point constraint set selection.
SPC$	M	Indicates restart with change in single-point constraint set selection.
SPC1	IB	Single-point constraint definition.
SPCADD	IB	Single-point constraint set combination definition.
SPCAX	IB	Conical shell single-point constraint definition.
SPCF	IC	Abbreviated form of SPCFØRCE.
SPCFØRCE	IC	Single-point constraint force output request. (UM-2.3, 4.2)
Spill	PH	Secondary storage devices are used because there is insufficient main storage to perform a matrix calculation or a data processing operation.
SPLINE	DBT	Splining Data Table.
SPLINE1	IB	Defines surface spline.
SPLINE2	IB	Defines beam spline.
SPLINE3	IB	User data to interpolate deflections at aerodynamic degrees of freedom.
SPØINT	IB	Scalar point definition card.
SSG1	FMS	Static Solution Generator - part 1.
SSG2	FMS	Static Solution Generator - part 2.
SSG3	FMS	Static Solution Generator - part 3.
SSG4	FMS	Static Solution Generator - part 4.
SSGHT	FMH	Solution generator for nonlinear heat transfer analysis.
STATIC	IC	Requests deformed structure plot for problem in Static Analysis.
STATICS	IA	Selects statics rigid format for heat transfer or structural analysis.
STATICS	P	Parameter used in SDR2 to indicate Static Analysis.
STEADY STATE	IA	Selects rigid format for nonlinear static heat transfer analysis.
STEREØSCØPIC	IC	Requests stereoscopic projections for structure plot.
STRESS	IC	Element stress output request. (UM-2.3, 4.2)
Structural Element	PH	One of the finite elements used to represent a part of a structure.
SUBCASE	IC	Subcase definition.
SUBCØM	IC	This subcase is a linear combination of previous subcases.
SUBSEQ	IC	Specifies coefficients for SUBCØM subcases.
SUBTITLE	IC	Output labeling data for printer output.
SUPAX	IB	Ficticious support for conical shell probl

SUPØRT	IB	Ficticious support definition card.
SVECTØR	IC	Request for output of eigenvectors in the solution set (D-7, D-10) (UM-2.3, 4.2).
SVELØ	IC	Abbreviated form of SVELØCITY.
SVELØCITY	IC	Requests velocity output for solution set. (UM-2.3, 4.2)
SYM	IC	Symmetry subcase delimiter card.
SYMBØLS	IC	Requests symbols at grid points on structure plot.
SYMCØM	IC	Assembly of symmetry subcase delimiter card.
SYMSEQ	IC	Assembly value of symmetry combination card.

T1	IC	Request for X-Y plot of the first translational component (UM-4.2).
T1IP	IC	Request for X-Y plot of the first translational component - imaginary and phase angle (UM-4.2).
T1RM	IC	Request for X-Y plot of the first translational component - real and magnitude (UM-4.2).
T2	IC	Request for X-Y plot of the second translational component (UM-4.2).
T2IP	IC	Request for X-Y plot of the second translational component - imaginary and phase angle (UM-4.2).
T2RM	IC	Request for X-Y plot of the second translational component - real and magnitude (UM-4.2).
T3	IC	Request for X-Y plot of the third translational component (UM-4.2).
T3IP	IC	Request for X-Y plot of the third translational component - imaginary and phase angle (UM-4.2).
T3RM	IC	Request for X-Y plot of the third translational component - real and magnitude (UM-4.2).
TA1	FMS	Table Assembler.
TABDMP1	IB	Tabular structural damping function for modal formulation (D-10, D-11, D-12).
Table Data Block	PH	A data block which is in tabular form rather than matrix form.
TABLED1	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED2	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED3	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLED4	IB	Dynamic load tabular function (D-8, D-9, D-11, D-12).
TABLEM1	IB	Material property tabular function.
TABLEM2	IB	Material property tabular function.
TABLEM3	IB	Material property tabular function.
TABLEM4	IB	Material property tabular function.
TABLES1	IB	Stress-dependent material tabular function for use in Piecewise Linear Analysis (D-6).
TABPCH	FMU	Punches selected tables on DTI bulk data cards.
TABPRT	FMU	Formats selected table data blocks for printing.
TABPT	FMU	Table printer.
TABRNDG	IB	Table of Power Spectral Density for certain gusts.
TABRND1	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND2	IB	Tabular function for use in Random Analysis (D-8, D-11).

TABRND3	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABRND4	IB	Tabular function for use in Random Analysis (D-8, D-11).
TABS	P	Defines absolute reference temperature in heat transfer analysis.
TALL EDGE TICS	IC	Request for plotting all edge tic marks on upper half frame for X-Y plots.
TAPE	M	Write data block on physical tape (see FILE).
TCURVE	IC	Curve title for X-Y plot.
TEMP	IB	Grid temperature definition card.
TEMPAX	IB	Temperature definition for conical shell problem.
TEMPD	IB	Grid default temperature definition card.
TEMPERATURE	IC	Selects the temperature set to be used in both material property calculation and thermal loading.
TEMPLD$	M	Indicates restart with change in thermal set for static loading.
TEMPMT$	M	Indicates restart with change in thermal set for material properties.
TEMPMX$	M	Indicates restart with change in thermal field with thermally dependent material properties.
TEMP(LØAD)	IC	Temperature set selection (applies to thermal load generation only).
TEMP(MAT)	IC	Temperature set selection (applies to material properties only).
TEMPP1	IB	Plate element temperature definition card.
TEMPP2	IB	Plate element temperature definition card.
TEMPP3	IB	Plate element temperature definition card.
TEMPRB	IB	One-dimensional element temperature definition.
TF	IB	Dynamic transfer function definition.
TF$	M	Indicates restart with change in transfer function set selection.
TFL	IC	Transfer function set selection.
TFPØØL	DBT	Transfer function pool.
THERMAL	IC	Request for output of temperature vector in thermal analysis (UM-2.3).
THRU	IC	Forms strings of values within set declarations.
TIC	IB	Transient Initial Condition set definition card.

TIME	IA	User time estimate for problem. This card if required in Executive Control Deck. Integer time value is in minutes.
TITLE	IC	Output labeling data for printer output.
TLEFT TICS	IC	Request for tic marks to be plotted on left hand edge of top half frame for X-Y plot.
TLØAD1	IB	Transient load set definition card.
TLØAD2	IB	Transient load set definition card.
TØL	DBT	Time output list.
TØL1	DBT	Reduced time output list, uses ØTIME.
Trailer	PH	A six word control block associated with a data block.
TRANRESP	P	Parameter used in SDR2 to indicate Transient Response Analysis (D-9, D-12).
TRANSIENT	IA	Selects rigid format for transient heat transfer analysis.
TRBSC	IC	Requests structure plot for all basic bending triangle elements.
TRD	FMS	Transient Response - Displacement.
TRHT	FMH	Integrates dynamic equation for heat transfer analysis.
TRIA1	IC	Requests structure plot for all TRIA1 elements.
TRIA2	IC	Requests structure plot for all TRIA2 elements.
TRIGHT TICS	IC	Request for tic marks to be plotted on right hand edge of top half frame for X-Y plots.
TRL	DBT	Transient Response List.
TRLG	FMH	Generates dynamic heat flux loads.
TRMEM	IC	Requests structure plot for all triangular membrane elements.
TRNSP	FMM	Transpose functional module.
TRPLT	IC	Request structure plot for all TRPLT elements.
TSTART	P	CPU time at start of flutter loop.
TSTEP	IB	Transient time steps for integration and output.
TSTEP	IC	Transient time step set selection.
TSTEP$	M	Indicates restart with change in transient time step set selection.
TUBE	IC	Requests structure plot for all TUBE elements.
TWIST	IC	Requests structure plot for all TWIST elements.
TYPE	IC	Indicates paper type for structure plots.

UBGV	DBM	Displacement vector for all grid points (D-4).
UBLL	DBM	$[U^b_{\ell\ell}]$ - Upper triangular factor of $[K^b_{\ell\ell}]$.
UBLV	DBM	Displacement solution vector (D-4).
UBØØV	DBM	Scalar multiple of UØØV in Differential Stiffness Rigid Format (D-4).
UDET	IB	Selects unsymmetric decomposition option for determinant method of real eigenvalue analysis.
UDV1T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT1. (D-9)
UDV2T	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem - SØRT2 (D-9).
UDVF	DBM	Displacement solution vector in a frequency response problem (D-8).
UDVT	DBM	Displacement, velocity and acceleration solution vectors in a transient analysis problem (D-9).
UEVF	DBM	Displacement vector for extra points in a frequency response problem (D-11).
UEVT	DBM	Displacement vector for extra points in a transient response problem (D-12).
UGV	DBM	Displacement vector for all grid points (D-1, D-2, D-4, D-5).
UGV1	DBM	Successive sums of incremental displacement vectors. Piecewise Linear Analysis Rigid Format only (D-6).
UHVF	DBM	Modal frequency response solution vectors (D-11).
UHVT	DBM	Modal transient response solution vectors (D-12).
UHVT1	DBM	Modal amplitudes for aeroelastic transient.
UINV	IB	Selects unsymmetric decomposition option for inverse power method of eigenvalue analysis.
ULL	DBM	$[U_{\ell\ell}]$ - Upper triangular factor of $[K_{\ell\ell}]$.
ULV	DBM	Displacement solution vector in static analyses (D-1, D-2, D-4, D-5).
UMERGE	FMM	Functional module to merge column matrices based on U-set.
UMF	IA	Requests User Master File as input source.
UMF	M	User Master File, a reserved NASTRAN physical file which must be set up by the user when used.
UMFEDIT	IA	Requests User Master File operational mode of NASTRAN.
Unmodified Restart	PH	Restarting (see Restart) a problem without changing any data, other than output requests, of the previous run.
Unpool	PH	Remove data block from Pool Tape and place on a file for use by a functional module.
UNSØRT	IC	Requests unsorted echo of Bulk Data Deck (ECHØ=UNSØRT).

UØØ	DBM	$[U_{oo}]$ - Upper triangular factor of $[K_{oo}]$.
UØØV	DBM	Partition of displacement solution vector.
UPARTN	FMM	Functional module to partition matrices based on U-set.
UPPER TICS	IC	Request for tic marks to be plotted on upper edge of frame for X-Y plot.
UPV	DBM	Transient solution vectors for all physical points.
UPVC	DBM	Frequency response solution vectors for all physical points.
USET	DBT	Displacement set definitions. (PM-1.7.3)
USETA	DBT	Displacement set definitions table - Aerodynamics.
USETD	DBT	Displacement set definitions including extra scalar points introduced by dynamic analysis. (PM-1.7.3)
UVT1	DBM	Displacements for aeroelastic transient.

V	DBM	Partitioning vector for set F to Ø and A.
V	M	Used in parameter section of DMAP statement. Indicates that parameter is variable and may be changed by module. If changed value is to be used in subsequent DMAP instruction, it must be saved (see SAVE).
VANTAGE PØINT	IC	Location of observer for structure plot.
VDR	FMS	Vector Data Recovery.
VDR	L	Used to skip to VDR module in flutter analysis.
VEC	FMU	Creates partitioning vector based on USET.
VECTØR	IC	Request for output of eigenvectors from real or complex eigenvalue analysis (D-3, D-5, D-7, D-10).
VECTØR	IC	Requests deformations on structure plot with vectors.
VELØ	IC	Abbreviated form of VELØCITY.
VELØCITY	IC	Output request statement for velocity vector. (UM-2.3, 4.2)
VFS	DBM	Partitioning vector for heat transfer analysis.
VIEW	IC	Rotation of object for structure plot.
VISC	IC	Request structure plot for all viscous damper element.
VPS	M	See XVPS.
VREF	PU	Velocity division factor.

W3	P	Pivotal frequency for uniform structure damping in the direct formulation of transient response problems (D-9).
W4	P	Pivotal frequency for element structural damping in the direct formulation of transient response problems (D-9).
WTMASS	P	Weight to mass conversion factor used in SMA2 and GPWG. Default value is 1.0.

X	IC	Requests X vector for deformed structure plot.
XAXIS	IC	Request for drawing of X-axis for X-Y plot.
XBAXIS	IC	Request for drawing of X-axis on bottom half frame for X-Y plot.
XBGRID LINES	IC	Request for drawing grid lines for X-axis on bottom half frame for X-Y plot.
XCSA	EM	Executive Control Section Analysis. The preface module which processes the Executive Control Deck and prepares the control file on the New Problem Tape.
XDIVISIØNS	IC	Request for division marking on X-axis.
XGPI	EM	Executive General Problem Initialization. The preface module whose principal function is to generate the ØSCAR. If the problem is a restart, XGPI initializes data blocks and named common blocks for proper restart.
XGRID LINES	IC	Request for grid lines to be drawn on X-axis for X-Y plots.
XINTERCEPT	IC	Specifies intercept of Y-axis on X-axis.
XLØG	IC	Request for logarithmic scales in X-direction.
XMAX	IC	Do not plot points whose X value lies above this value.
XMIN	IC	Do not plot points whose X value lies below this value.
XPAPER	IC	Specifies length of paper in X-direction for table plotter.
XQHHL	P	Appended QHHL data parameter.
XSFA	EM	Executive Segment File Allocator - the administrative manager of data blocks for NASTRAN.
XSØRT	EM	Executive sort routine - the preface module which reads and sorts the Bulk Data Deck and writes the sorted Bulk Data Deck on the New Problem Tape.
XTAXIS	IC	Request for drawing of X-axis on top half frame.
XTGRID LINES	IC	Request for drawing of grid lines on top half frame.
XTITLE	IC	X-axis title for X-Y plots.
XVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
XVPS	M	Variable Parameter Set Table. Executive table needed for restart. (PM-2.4)
XY	IC	Requests X and Y vectors for deformed structure plot.
XYCDB	DBT	SØRT3 type output requests (XYPLØTTER, XYPRINTER, Random Request).
XYØUT	IC	Request to generate X-Y plots.
XYØUT$	M	Indicates restart with an X-Y plot request.
XYPEAK	IC	Request to print the maximum and minimum values of the specified response.
XYPLTCE	DBT	XY plot input data block, complex flutter.

XYPLØT	FMS	X-Y plot generator.
XYPLØT	IC	Request to generate X-Y plots.
XYPLTF	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTFA	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTR	DBT	XYPLØT input data block. (D-8, D-11)
XYPLTT	DBT	XYPLØT input data block. (D-9, D-12)
XYPLTTA	DBT	XYPLØT input data block. (D-9, D-12)
XYPRINT	IC	Request to tabulate XY pairs on the printer.
XYPRNPLT	FMU	Dummy output module.
XYPTTA	DBT	XY plot input data block, aeroresponse.
XYPUNCH	IC	Request to punch XY pairs.
XYTRAN	FMS	XY output translator.
XYZ	IC	Requests X, Y and Z vectors for deformed structure plot.
XZ	IC	Requests X and Z vectors for deformed structuer plot.

Y	IC	Requests Y vector for deformed structure plot.
Y	M	Used in parameter section of DMAP statement. Indicates that parameter may be given an initial value with a PARAM bulk data card.
YAXIS	IC	Request for drawing of Y-axis.
YBDIVISIØNS	IC	Request for division marking on Y-axis of lower half frame.
YBGRID LINES	IC	Request for grid lines to be drawn on Y-axis of lower half frame.
YBINTERCEPT	IC	Specifies intercept of X-axis on Y-axis on lower half frame.
YBLØG	IC	Request for logarithmic scales in Y-direction on lower half frame.
YBMAX	IC	Do not plot points whose Y value lies above this value for lower half frame.
YBMIN	IC	Do not plot points whose Y value lies below this value for lower half frame.
YBS	DBM	Scalar multiple of YS matrix. Used in Differential Stiffness Rigid Format only. (D-4).
YBTITLE	IC	Y-axis title on lower half frame.
YBVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YDIVISIØNS	IC	Request for division marking on Y-axis.
YES	IA	Option used on CHKPNT card, indicates that checkpoint is desired.
YGRID LINES	IC	Request for grid lines to be drawn on Y-axis.
YINTERCEPT	IC	Specifies intercept of X-axis on Y-axis.
YLØG	IC	Request for logarithmic scales in Y-direction.
YMAX	IC	Do not plot points whose Y value lies above this value.
YMIN	IC	Do not plot points whose Y value lies below this value.
YPAPER	IC	Specifies length of paper in Y-direction for table plotter.
YS	DBM	$\{Y_s\}$ - Constrained displacement vector.
YTDIVISIØNS	IC	Request for division marking on Y-axis for upper half frame.
YTGRID LINES	IC	Request for grid lines to be drawn on Y-axis for upper half frame.
YTINTERCEPT	IC	Specifies intercept of X-axis on Y-axis for upper half frame.
YTITLE	IC	Y-axis title.
YTLØG	IC	Request for logarithmic scales in Y-direction for upper half frame.

YTMAX	IC	Do not plot points whose Y value lies above this value for upper half frame.
YTMIN	IC	Do not plot points whose Y value lies below this value for upper half frame.
YTITLE	IC	Y-axis title for upper half frame.
YTVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval for upper half frame.
YVALUE PRINT SKIP	IC	Request to suppress labeling tic marks over the specified interval.
YZ	IC	Requests Y and Z vectors for deformed structure plot.
Z	IC	Requests Z vector for deformed structure plot.

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